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INDUSTRIAL SHELLS OF THE PHILIPPINES

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EIGHTEEN PLATES

Shells of Philippine mollusks have been put to many and varied uses since the earliest times. Before the Spanish occupation no specific mention regarding the use of marine shells for ornaments and in trade and barter has come to the attention of the writers, but it is not difficult to imagine that they were used as ornaments or in exchange for other things as was the custom in some of the islands in the West Pacific.

The accounts of early Spanish historians have references to the uses made of the different shells. About 1570, the natives of Mindoro were blowing horns made of shells.¹ Species of *Tridacna* have been mentioned as used for a watering trough and as a holy-water font. From the same shell some of the people were supposed to have made saws, which they sharpened by rubbing the shells against certain stones. Other uses of shells mentioned are as drinking cups, tweezers, censers, and others of general character. The inhabitants of Camarines Provinces used helmets set with fishbones and stout shells. Those in Zambales used shells as marks of distinction, those who had killed more than nineteen persons wore certain very highly colored *sigueyes* (shells). It is recorded that the early inhabitants made use of shells as a medium of exchange, as tribute offerings, as ornaments, as a source of lime, as panes for windows, and as a source of pearls.

¹ Most of these historical references are taken from E. H. Blair and J. A. Robertson. *The Philippine Islands*. Clark, Cleveland, Ohio (1903-1909) 8°, 55 vols.

At the present time large *Tridacna* shells are used in many churches as holy-water fonts. Some of the Batan islanders use certain kinds of miter shells for pipes. Fishermen in the Visayas occasionally use shells to make clarion calls. The present report, however, will deal only with those shells used on a commercial scale, and that are gathered in sufficient quantities to enter into our commercial statistics. These shells are the pearl shells, the trochus shells, the turban shells (all used for button making), the window shells, and the pearly nautilus.

The information given in this paper, particularly regarding the life histories and habits of these mollusks, has been compiled from the personal notes of the writers and from all available literature. The articles in the Philippine Journal of Science have been freely used. Due acknowledgment is hereby made to the various authors consulted.

The writers also wish to acknowledge with thanks the help extended and courtesies shown them by the shell factories in the City of Manila and by the shell dealers in the provinces.

GOLD-LIP PEARL SHELL (PLATE 1)

Common names: Pearl oyster, pearl shell, gold edge, gold lip, silver lip.

Local names: *Concha blanca* (Sp.), *concha* (Tag.), *tipay* (Vis.), *tipay bas* (Tausug).

Trade names: Manila, Sulu, Singapore, Port Darwin, West Australian, Queensland, New Guinea, Mergui, Macassar (Sydney or Aroes).

Scientific name: *Pinctada maxima* (Jameson) = *Margaritifera maxima* (Jameson) = *Meleagrina maxima* (Jameson) = *Pteria maxima* (Jameson).

DESCRIPTION

Shell orbicular, thick, massive, flatly convex, margin rounded except on the side of the hinge, where it is straight. Exterior concentrically laminated, laminæ produced towards the margin into lappetlike processes, forming more or less irregular twisted scales, fragile and rather transparent. Color pale yellowish brown with traces of radial markings of other colors. Interior light golden brown, nacre silvery white, lustrous, with a broad golden border, and plenty of "fire" (many-colored iridescence).

The shell figured has the following measurements: Height, 20.5 centimeters; breadth, 20.5; diameter, 4.2; length of hinge, 13.

OCCURRENCE AND DISTRIBUTION

The gold-lip pearl shell is widely distributed throughout the Philippine Archipelago, occurring in waters from 5 to 40 meters in depth. It is more or less abundant in certain localized areas. The region from Basilan to Borneo, comprising the entire Sulu Archipelago, is one extensive pearling bank, covering an area of about 35,000 square kilometers, the largest and the most prolific in the Philippines. Natural beds exist in Davao Gulf, Illana Bay, Mindanao; at Cagayan Sulu, Palawan, Cuyo, Bohol, Cebu, Bantayan, Masbate, Ilacaon, Gigantes, and Guimaras Islands; New Washington, Balasan, and Estancia, Panay; Masinloc Bay, Zambales; on the western and northern coasts of Samar; and around Cape Engaño, Polillo Islands, and the Batan group.

Life history and habits.—The gold lip inhabits warm seas, from 5 to 120 meters in depth, where the ocean currents are strong and where the water has a specific gravity of about 1.022 and a temperature of from 23° C. to 35° C. It thrives well in clear water on suitable bottoms of sand or coarse gravel with dead corals or rocks or ooze formed by the deposits of foraminifera and globigerina, with growth of eel grass and other submerged plants. Except during the larval period, the oyster is more or less stationary, although it is not uncommon to find it removed through such agencies as tidal currents or man, rather than through its own power of movement. It can move about for several centimeters only by casting off the organ of attachment and using the foot.

The sexes of this species are distinct and separate; that is, the individual is either male or female. The mature female produces several thousand eggs. These when ripe are discharged into the sea water to be fertilized by the male element. The meeting between the reproductive substances is left entirely to chance. The eggs are pear-shaped and buoyant at first, becoming rounded after fertilization, and thereafter the resulting trochophores develop cilia that enable them to swim and drift. During this stage the young are in great danger. They are exposed to the mercy of tides, currents, winds, and waves that may carry them away from their paternal habitat. In about forty-eight hours the larvæ reach the veliger stage and develop shells; and in from four to five days they settle down or set on any object upon which they chance to fall. The shelled larvæ are now known as spat and are about 1 centimeter in length. Hairlike bristles, collectively called the byssus, appear with

which the young oysters are enabled to anchor themselves to any hard object. If attached to floating material, they seek the under or shady side, as they are highly sensitive to sunlight. Soon they drop off and sink and then adhere to any resisting object by means of the byssus. A single thread of this organ is sufficient to insure fixation.

The growth rate of the gold lip is fairly rapid in the Philippines. In the Sulu Archipelago it is sexually mature in two years and has been observed to spawn during the months from May to September, although it seems capable of performing the generative functions at every season of the year. The frequency at which it emits sexual products within the period of one year in any one particular locality in the Philippines has never been ascertained. It is probable that there are periods during which the spawn are more abundant than at other times and that spawning does not occur at the same time in all the islands of the Philippine Archipelago, nor even in all islands of one group, such as, the Sulu Archipelago or the Bantayan group. In three or four years, when it is most valuable commercially, the gold lip attains a size of from 18 to 23 centimeters in its greatest outside long-axis measurement; that is, the distance from the hinge to the lip. At this age the nacre measurement taken at right angles to the hinge is at least about 14 centimeters, the minimum legal size limit for this species. Under favorable conditions a mature oyster may in less than three years overreach this requirement. The maximum age and size of the gold lip are not very well known. Large specimens have been secured now and then that most probably are more than 10 years old. These are generally worn out, encrusted with sponges or badly riddled by boring mollusks and worms.

No artificial cultivation of pearl oysters or pearls is conducted anywhere in the Philippines. The Sulu Archipelago and the Bantayan Islands have sheltered recesses where pearl shells may be transplanted and cultivated or cultured for pearls. For this purpose, concessions should be granted to be leased for say ten or twenty years, with adequate protection by the Government; otherwise, it would be extremely difficult to carry on the experiment successfully, as such farms are always exposed to harmful attempts on the part of the misguided, ill-intentioned element of the community. The cultural method used successfully in Japan could be profitably carried on, if properly developed and protected, in certain favorable localities in the Philippines. Preliminary experiments on culture pearls conducted by Mr.

Kashiwagi in 1929 in the water in front of the town of Jolo revealed significant and encouraging information on the comparatively rapid growth of nacre around the inserted shell nuclei. Spherical shell beads 5 millimeters in diameter were introduced into the soft parts between the mantle flaps of 2-year-old gold-lip oysters. The operation is very delicate, requiring skill and a thorough knowledge of the anatomy of the vital parts. The treated mollusks were placed in wire baskets and lowered into the channel near the town of Jolo and were inspected every month. In the course of inspection it was discovered that the wire baskets were disappearing gradually. Since these were adequately weighted against the currents in the channel, the reason for their disappearance was, therefore, not very difficult to find. The experiment was exposed to human depredation, but could have been carried on to a more successful conclusion if properly protected. However, in shells that were recovered after thirteen months the beads were coated with nacre and appeared as perfect as any natural pearls, with a bluish luster. The shell beads had increased in diameter from 5 to 7 millimeters. This information seems to indicate that culture pearls can be grown successfully in the Philippines, and if properly handled and adequately protected the cultural farms could be made a source of considerable revenue.

From the fertile grounds of Mindanao and Sulu in particular, and from the northern beds in general, pearl shells are obtained by skin and armored divers. The former work from native dugouts (*vintas* or *bancas*), and the latter from luggers. Formerly, one-masted pearling yachts were in common use, but at present, the two-masted types are more generally employed. Practically all are motor boats with engine air pumps. The boats range from 8 to 16 tons in gross tonnage and usually carry a crew of eight or nine men; namely, the captain, the supercargo, two divers, one or two engine men, a cook, and two or three sailors. The supercargo is generally the owner of the boat himself or his representative. In smaller luggers the captain is also one of the divers. Generally, when operating, the boat is not anchored, and since the work is done at the slack of the tide, she can be managed to float practically at a standstill. In places where the current is strong it is necessary to anchor the boat before diving is done.

Armored diving requires the use of a diving suit, or scaphander, which is composed of a one-piece rubberized cotton-cloth suit, copper headgear or helmet, copper corselet to which

the helmet is screwed, leaden-soled boots, and chest and back weights. With these accessories a diver is enabled to remain under water for a longer period and to dive in weather that would prohibit naked diving and to go to deeper waters and to work in a systematic manner. As soon as dressed the diver is helped to his position on a ladder hanging over the side of the boat. The necessary attachments are put in place; the air pipe, the life line or tender line, and the helmet are attached; the air pump is started, the face glass screwed tightly, and the air release valves opened. When everything is ready, the diver descends and then lets go his hold plunging backwards into the water and sinking quickly to the quiet depths below. He carries a hoopnet capable of holding fifteen pairs of ordinary-sized gold-lip shells. In his first dive the diver remains under water for but a short time, say, from ten to twenty minutes. This is necessary for his readjustment to the condition below. As soon as he is ready to ascend he signals to the tender who pulls him up slowly. The diver does not come out of the water immediately, but remains about five meters below the surface for about two-thirds the length of his working time on the bottom. This is an important precaution in order to avoid a sudden change in pressure; that is, to permit the pressure of the air to be released from the blood gradually.

The physical as well as the physiological condition of the diver determines, therefore, how long he can work on the bottom and how many times he can go down in a day. Generally, the dive lasts from fifteen to twenty-five minutes, and rarely exceeds thirty minutes; five dives a day are considered a fair average.

Armored diving is very strenuous as well as dangerous, and only those of robust constitution can continue in this occupation without impairing their health. Records show that there are more casualties resulting from constitutional injuries than from the attacks of sharks or other fishes or from the fouling of the air hose.

In the pearl-shell fisheries in the Philippines there are many experienced licensed armored divers, among whom are Moros, Christian Filipinos, and Japanese. The Japanese are recognized masters in armored diving, but the Filipinos are apt pupils, and there are several that can equal if not excel the best of the Nipponese divers.

Pearl-shell fishing in the Philippines is going on the year round, both for the pearls and for the hard shells, which are in

great demand in the manufacture of buttons and use in other crafts. The Sulu pearls are noted for their excellent quality and have been known in the markets of the world for four hundred years. It has been claimed that the pearl industry in Sulu has been on the decline because of the decrease in price of shells; but the fisheries have continued to yield an ample number of good pearls. And it may be considered that the collection of pearl shells is only incidental to the real objective of every boat owner, since the income from the mother-of-pearl alone cannot defray all the expenses for operation and repair of the boats.

AMOUNT AND VALUE OF SHELLS

The total amount of unmanufactured gold-lip shells exported from the Philippines to the United States, Great Britain, Germany, Spain, British East Indies, Hongkong, and Japan in 1927 was 247,412 kilograms valued at 191,491 pesos and in 1928 was 214,782 kilograms valued at 166,158 pesos.

The port of Jolo exported over 100,000 kilograms of unmanufactured gold-lip shells valued at 108,917 pesos to Sandakan and Singapore in 1929; and during the first nine months of 1930 the shells exported to the same countries totaled 20,013 kilograms valued at 17,776.60 pesos.

The export from the port of Zamboanga to Singapore and London amounted to 11,727 kilograms, valued at 10,821 pesos, in 1928; 3,951 kilograms, valued at 3,215 pesos, in 1929; and 12,312 kilograms, valued at 13,667.35 pesos, during the first six months of 1930.

During the present year (1930) the price of the gold lip fluctuated between 38 and 45 pesos per picul² at the fishing centers and reached as high as 53 pesos per picul in Manila. On the whole, these prices are considerably below those of fifteen years ago. It is feared that the local trade in pearl shells will not recover its former status in the face of stiff competition from Borneo and other southern foreign ports. The button factories in Manila receive regular consignments from Sandakan, Kudat, and Singapore.

The major part of the pearl shell obtained in southern waters enters the custom houses in Jolo, Zamboanga, and Davao, and is exported to London and Paris via Singapore, or to Sandakan for the Oriental markets; only a small percentage of the crop gathered from these grounds reaches Manila directly from the

² One picul (or pico) = 63.25 kilograms = 139.44 pounds.

three southern ports. The two button factories in Manila; namely, the Philippine Button Corporation on Misericordia Street and the Manila Button Factory at Pandacan, receive raw materials from Polillo, Aparri, Bantayan, Cebu, Bohol, Cuyo, and Palawan, and in addition get consignments from Singapore, which is a rather significant fact. Singapore is the big market for shells collected from the adjacent regions, and the fact that shells are much cheaper there than in the Philippines enables that port to trade with Manila. This competition is partly responsible for the general low prices of pearl shells in the local markets.

UTILIZATION

The gold lip is utilized primarily in the manufacture of buttons, but it is also used in a great variety of practical and artistic articles. From this shell are manufactured such novelties as fish and salad plates, nut dishes, salt dishes, olive and pickle forks, and ice-cream spoons and dishes. Handles for knives, hand mirrors, opera glasses, umbrellas, canes, and similar objects are made from the finest grades of mother-of-pearl. It is highly adapted to the making of belt buckles, shoe buckles, bar pins, beads, studs, cuff links, and hat pins, and to the ornamentation of fancy work or inlays of furniture, clocks, inkwells, picture frames, cigarette and vanity cases, pencils, and fountain pens. The meat is prepared as food.

BLACK-LIP PEARL SHELL (PLATE 2)

Common name: Black lip.

Local names: *Concha negra* (Sp.); *tipay batu* (Tausug); *tipay tipay* (Vis.).

Trade names: Black lip, Bombay, Tahiti, Gambia, Auckland, Panama, Hikueru, Banda.

Scientific name: *Pinctada margaritifera* (Linnæus)=*Avicula margaritifera* Lamarck=*Margaritifera margaritifera* Linnæus=*Meleagrina margaritifera* (Linnæus)=*Pteria margaritifera* (Linnæus).

Description.—Shell orbicular, generally somewhat more convex than *Pinctada maxima* (Jameson), smaller, and the hinge margin shorter. Exterior greenish or dark brown marked with radial rows of white spots running from the umbo to the margin. Nacre highly iridescent, somewhat steely in luster, with a dark smoky marginal band.

The shell figured has the following measurements: Height, 12 centimeters; breadth, 12; diameter, 2.6; length of hinge, 6.5.

DISTRIBUTION AND OCCURRENCE

The black-lip pearl oyster is more widely distributed than its larger congener, the gold lip. In the Philippine Archipelago it is common in waters from 2 to 30 meters in depth along the shores of almost all the islands. The most important grounds are in the Sulu group, Cuyo Islands, Bohol, Tañon Strait, Cebu, Bantayan; on the northern coast of Negros and the southern and eastern shores of Guimaras Island; off Balasan, and New Washington in Capiz; around Masbate, Leyte, Samar, Sibuyan, and Mindoro; in some bays along the coast of Zambales and in Lingayen Gulf; along the shores of Cagayan, Tayabas, the Bicol Peninsula, and the Batan Islands.

This species, like its close relative, occurs in warm, temperate and tropical seas. It thrives well in bottoms of coarse sand with dead coral or rock and plant growth to which the young may attach. It is a notable fact that pearl oysters cannot grow on living coral. They rarely survive in sandy places where the currents make sand burial a common occurrence.

LIFE HISTORY AND HABITS

The life history of this species is essentially similar to that of the gold lip. The course of its natural life follows the usual stages that a unisexual bivalve undergoes. The female produces numerous eggs, which are fertilized by chance in the water by the sexual products of the male. The larvæ resulting from the union are by nature and structure planktonic; that is, buoyant and floating on the surface. As such their life in the open sea is exceedingly precarious as they are at the mercy of the elements, which may carry them away from their parental surroundings. At the end of from thirty to forty-eight hours, after passing through the trochophore and veliger stages they become shelled larvæ; and at the end of the third day their roving adventure ceases as they sink and attach themselves to hard objects they chance to fall upon. They are now known as spat. Their attachment is made possible by the aid of the sticky threads of the byssus. The ropelike "roots," however, may wear off any time but new growths almost immediately appear, for it is essential that the growing mollusks adhere to some resisting collector. It has been asserted that pearl oysters torn from their original attachment and deprived for a considerable period of any collector for the byssus to adhere to perish soon. In their natural environment, these mollusks lie with the right, or less convex, valve beneath and with the

posterior edge of the shell elevated at an angle of about 20 degrees.

The growth of the black lip is comparatively rapid in Philippine waters, since there are no abrupt changes in the surroundings to retard or suspend its development. It does not "rest" as the shells generally do in temperate or cold regions. The size and age at which this species is sexually mature are as yet not definitely ascertained; there is, however, a fair indication that it starts to spawn at a small size and at the age of a little over a year. Female specimens of about 9 centimeters in length were found to contain ripe ova, and male individuals 15 centimeters in length were also found sexually ripe. It has been observed that at about two years of age it attains the present legal size of 9 centimeters, nacre measurement taken at right angles to the hinge joint; or about 11 centimeters, maximum outside long-axis measurement taken at right angles to the base. Undoubtedly the black lip continues to grow, as large shells 14 centimeters and over in external measurement are now and then found. These overgrown individual shells, however, are useless or of little value because they are invariably dead, covered with coral or sponge growths, and well perforated by boring mollusks or worms. In oysters of legal size and above, pearls are usually produced, but these are black and almost always of dead luster and have, therefore, very little commercial value, so that fishing for the black lip is done primarily for its mother-of-pearl alone.

At no place in the Philippines is artificial cultivation of this species carried on. There are favorable localities in the Visayas and in Sulu where pearl-oyster farming may be profitably conducted, but work of this nature may not go beyond the experimental stage for some time as there are serious difficulties connected with it.

As this species is more abundant in shallow waters, the use of "machine diving" is practically dispensed with. In the southern region the divers have three other ways of gathering the pearl shells; namely, by actual diving, by dredging, and by a three-pronged catcher drawn by a rattan rope. The last method can be used only in quiet clear water, since it is only effective when the fisherman in the boat can see the shells at the bottom. On the whole, skin or naked diving is generally preferred. The divers go down at random and search for shells after reaching the bottom. This method still persists although it is uncertain

and wasteful in both time and energy. Quite recently, however, a labor-saving device, the water glass, was introduced. The glass, which may be in the form of a pail or flower pot with glass bottom, is used to aid the diver in scanning the grounds. With this it is possible for him to locate in clear water the shells on the sea floor 30 to 50 meters in depth. It is now widely used by the Moros and other divers in the Philippines. Also, the so-called fishermen's goggles have become popular with them.

The Moros are the most expert naked pearl divers in the Philippines. They are exceptionally hardy, skillful, and daring sailors and fishermen for whom the sea has an intense fascination. The tales of their exploits and adventures in the treasure realm of the deep are accounts of romantic as well as economic significance.

When a Moro skin diver is ready to plunge he fills his lungs several times and then expels the air slowly. Then he takes a deep breath and sinks a few feet below the surface, quickly dives to the bottom, where he collects as many shells as possible. As soon as he reaches the limit of his staying power, he straightens himself, and pushing with his feet on the bottom springs upward, shooting to the surface with startling speed. He delivers his catch to his companion in the *vinta* and rests for a moment before repeating the performance. Generally when diving in deeper water, a naked diver goes down with the aid of a heavy stone attached to a rope.

Each diver may carry a bagnet in which he places his catch; or a sort of basket woven from fish nets is lowered to the bottom to be used by the members of one outfit, which generally consists of an outrigger dugout, or *vinta*, and two to five divers with their families.

Few, if any, Moro naked divers venture in water deeper than 35 meters. It is probable that there are Moro skin divers who can go deeper, but it is certain that their working time is very limited indeed. Twenty meters may be considered good diving, and in many of the grounds in Sulu worked by naked divers the depth of the water is even less than 10 meters. The number of those that can remain under water longer than two and a half minutes is very small, and it is doubtful whether there is any Moro naked diver who can stay under for three minutes, reports and claims to the contrary notwithstanding.

In the Sulu Archipelago hundreds of *vintas* may be seen along

the shallow waters between small islands busily engaged in naked pearl-shell diving. Men, women, and boys all join in the occupation. The women on board open the shells, take the meat out and dry it in the sun. The shells are cleaned and placed in the hold of the boat. The Moro naked divers work for themselves; few, if any, work under contract.

AMOUNT AND VALUE OF BLACK-LIP SHELLS EXPORTED

The total amount of shells obtained annually from the Philippine pearl-shell banks, while not accurately known, is calculated to be not less than 20,000 kilograms valued at about 6,000 pesos. During 1928, the port of Jolo exported 2,205 kilograms of unworked shells valued at 355 pesos to Sandakan and Singapore; during 1929, 4,328 kilograms valued at 1,100 pesos; and during the first six months of 1930, 257 kilograms valued at 80 pesos. Cebu exported in 1928 to London 63 cases of "common shells" valued at 2,500 pesos. The classification used in the invoice is very indefinite, but there is no doubt that a few black-lip shells went with that consignment. Zamboanga exported 12,477 kilograms of M. O. P.³ shells valued at 11,821 pesos to London and Singapore during 1928; 4,951 kilograms of M. O. P. shells valued at 3,210 pesos to Singapore and London during 1929; and 12,312 kilograms of M. O. P. shells valued at 13,667 pesos to London during the first five months of 1930. The exact amount and value of the black lip included in these exports are not known. Legaspi, Iloilo, and Davao reported no exportation of black-lip shells during 1928, 1929, and up to the first six months of 1930. The two button factories in Manila receive shipments of black-lip shells from the Visayas, Zambales, Pangasinan, Cagayan, and Tayabas, which run into several thousand kilograms. The price of black lip in Sulu and in other places in general is around 18 pesos per picul; in Manila it is a trifle over 20 pesos per picul.

UTILIZATION

The black-lip shells are used in the manufacture of common and fancy buttons for overcoats and cloaks, of inlaid works, of cameos, and of jewelry and miscellaneous objects. The meat is utilized extensively as food, either boiled or dried. In the Sulu Archipelago, the pearling crews derive a considerable income from the dried flesh of the pearl oyster, which they sell to the Chinese who use it in preparing nutritious soups and dishes.

³ M. O. P. means mother-of-pearl. M. O. P. shells consist of a combination of gold-lip and black-lip pearl shells.

TOP SHELLS

Common names: Top shell, conic shell, loch, trochus.

Local names: Trocas (Sp.); simong or samong (Vis.); lak (Tausug); Susong dalaga (Tag.); chin leh (Chinese).

Trade names: Trochus, top shell, trocas, trochas.

SPECIES COMMERCIALY USED

Smooth variety *Trochus niloticus* Linnæus

Trochus maximus Koch

Rough varieties *Trochus obeliscus* Gmelin

Trochus noduliferus Lamarck

The great majority of the shells used are the smooth variety, *T. niloticus* Linnæus. The rough varieties, *T. maximus* Koch and *T. obeliscus* Gmelin together would probably not constitute 20 per cent of the total consumption. *Trochus obeliscus* is generally referred to in trade as the "female." The other rough variety, *T. noduliferus* Lamarck, is seldom met with.

TROCHUS NILOTICUS LINNÆUS

Shell conical, thick, subperforate, covered by a corneous, striate, brown or yellowish cuticle lost on the upper whorls; color beneath the cuticle silvery white, longitudinally, somewhat obliquely, striped with crimson or reddish brown, base spotted with radiating lighter shade of the same color. Spire strongly conical, apex acute, whorls 8 to 10, generally 9, first two smooth or eroded, following four spirally beaded and tuberculate at the sutures, remaining whorls smooth and flat on their outer surface, separated by linear sutures, the body whorl expanded, dilated and compressed at the obtuse periphery, more or less convex below, indented at the axis. Columella oblique, terminating in a denticle below and with a strong fold above, deeply inserted in the axis. Umbilical tract covered by a spiral deeply entering callus. Aperture transverse, very oblique. Height, 75 to 100 millimeters; diameter, 80 to 120.

TROCHUS MAXIMUS KOCH

Shell very similar to *Trochus niloticus* Linnæus, only somewhat less ponderous but more strictly conical. Whorls decidedly plicate or tuberculate, body whorl not dilated at the periphery, more or less flat at the base. Columella less oblique.

TROCHUS OBELISCUS GMELIN

Shell solid, imperforate, thick, spire more or less acute above. Color greenish more or less mottled with brown, base white, inside pearly. Whorls 12, occasionally 13 or 14, upper ones

slightly exserted and plicate, tuberculate or undulating at the sutures, encircled with one or two spiral series of small tubercles, which are increased to five or seven on the lower whorls; angulate at the periphery. Base flat, with shallow concentric grooves. Aperture oblique, outer wall grooved within, basal margin straight, deeply notched at its junction with the columella. Columella with strong acutely carinated spiral fold. Height, 75 millimeters; diameter, 75.

TROCHUS NODULIFERUS LAMARCK

Shell solid, imperforate, conic pyramid. Color whitish pink, more or less mottled with rose (old specimens grayish). Whorls 10 to 12, prominently knobbed around the sutures and periphery, the tubercles from fourteen to sixteen on the last whorl. Base flat, polished, with shallow concentric grooves, white or tinged with green around the central portion. Aperture smooth within. Columella fold strong, heavy, directed downward. Height, 70 millimeters; diameter, 75.

OCCURRENCE AND DISTRIBUTION

The top shells are widely distributed throughout the Philippines, appearing abundantly in many of the islands. They are usually found near the outer edge of coral reefs where they occur more or less singly; and while a few may be met with under a large stone they never are in great numbers over a given limited area.

These shells may be secured in quantities in the shallows around Sitanki and Tawitawi; in Davao Gulf; along the east coast of Mindanao and the north and west coasts of Palawan; around Cuyo, Bantayan, and Cebu; along the east coast of Bohol and the north and west coasts of Negros; around Lingayen Gulf and along the coasts of Tayabas, Camarines Norte, and Camarines Sur. The north coasts of Mindoro and Lubang Island, east coast of Masbate, north and west coasts of Samar, and the rocky shoals of Leyte and Sibuyan also yield considerable numbers. In general, all the coral reefs and shallow rocky bottoms around the small islands of the Archipelago are natural sources of top shells. The mollusks are collected by wading along the reefs or by skin diving in water from 2 to 15 meters deep.

LIFE-HISTORY AND HABITS

In the Philippines, the facts regarding the breeding season of the top shells and the size at which they start to spawn are not

definitely ascertained. According to Seale⁴ the great top shell (*Trochus niloticus*) reaches maturity in three years. It is well known that the sexes of top shells are separate; that is, the individual is either male or female. The reproduction is always by eggs, which are laid on rocks or glued to seaweeds in masses. The meeting of the eggs and spermatozoa takes place in the water and is left entirely to chance. From the fertilized egg is developed the trochophore in which the nearly spherical embryo grows a circlet of bristles or cilia. This circle of hairs separates the portion bearing the mouth and anus from the rest of the body. The trochophore is transformed into the veliger, in which the cilia become elongated and are pushed to the front of the embryo while the part of the body from which the bristles arise becomes elevated and develops on each side a more or less distinct lobe, the velum. In this stage the shell gland and visceral sac appear on the upper part and the foot is seen on the lower. The veliger swims about in the sea, until the increasing weight of its shells forces it to settle to the bottom. The young gastropod is capable of moving about for a considerable distance. It crawls by means of its powerful foot along the edges and bottoms of rocks in search of food, which consists of sea algæ and various organic substances. It is primarily vegetarian, subsisting upon dead or decaying vegetable matter.

AMOUNT AND VALUE OF SHELLS

There is no way of determining accurately the total annual amount of trochus fished in Philippine waters. However, a close estimate of the yearly quantity of collected shells that are disposed of commercially, either as unworked material for export or for domestic use, may be derived from the records at the ports of entry and from the reports of the Insular Collector of Customs.

The Philippine exports of trochus shells to China, British East Indies, and Japan amounted to 113,626 kilograms valued at 8,715 pesos in 1927, and 81,514 kilograms valued at 11,064 pesos in 1928. The port of Jolo exported to Sandakan and Singapore 1,587 kilograms of top shells valued at 1,032.70 pesos in 1929, but none during the first half of 1930. A fair amount is occasionally shipped from Jolo to the two button factories in Manila. Shells entered at Jolo are obtained from the Sulu beds and along the southern coast of Palawan.

⁴ Philip. Journ. Sci. § D 11 (1916) 263.

During 1930 trochus shells were sold from 40 to 48 pesos per picul in Jolo and Zamboanga, and in Manila the price reached as high as 52 pesos per picul.

UTILIZATION

Trochus shells are used chiefly in the manufacture of buttons. The meat is also utilized for food, and a considerable number of shells become cheap or unusable for industrial purposes as a result of the common practice among native fishermen of boiling or burning the shells in order to extract the meat. The heat destroys the luster of the shells, consequently their value in button making is greatly reduced. The shells should be buried in the sand for at least a month and then washed in sea water. The natural sheen of the shells is never impaired by this process. This is by far the most practical method of preparing the top shells for industrial purposes. Besides buttons, many beautiful objects for home and office, bric-a-brac, jewelry, and small ornaments are made from the pearly shells of trochus.

TURBAN SHELLS (PLATE 8)

Common names: Green snail, sea snail, turbo.

Local names: *Lalong* (Tag.); *bolalo* (Vis.); *lagong*, *laong* (Tausug); *tua leh* (Chinese).

Trade names: Green snail, turban shell, turbo.

Scientific name: *Turbo marmoratus* Linnæus.

DESCRIPTION

Shell large, turbate, solid, imperforate, ventricose, green, marbled with white and reddish brown. Whorls 6 to 7, smooth or concentrically striated, the first two yellow or yellowish white, the last very large, flattened or concave above, bearing two nodose keels below and a nodose carina above. Aperture large, interior pearly, columella arched, bearing a transverse fold more or less ear-shaped. Operculum white, subcircular, thick, somewhat concave within. Height, 150 millimeters; diameter, 155.

OCCURRENCE AND DISTRIBUTION

Closely associated with the top shells, the green snail is found throughout the Philippine Archipelago; the distribution is so widespread that there is hardly a rocky islet or coast that does not harbor this mollusk. It occurs in greatest abundance along the edges of coral reefs and in water several meters deep. A number of turban shells may be encountered under large bowlders along rocky shores.

Fairly extensive turbo fisheries exist in certain localities in the Sulu Archipelago. Sitanki and Tawitawi and the adjacent islands near Siasi yield considerable quantities of green snails. The north and west coasts of Palawan are natural grounds. The Batan, Cuyo, and Bantayan groups are exceptionally rich in turbos. The coral reefs and shoals along the north and west coasts of Negros have contributed to the shipment from Cebu. The Visayan islands on the whole may be regarded as productive grounds for this species. From the coasts of Pangasinan, Cagayan, Tayabas, Camarines Norte, and Camarines Sur large numbers of turban shells are secured and sent to Manila.

LIFE-HISTORY AND HABITS

Like the top shells, the green snail is unisexual; that is, the individual is distinctly male or female. In these two species the stages of development from the fertilized egg to the veliger are essentially similar. The resulting small snail is an active bottom dwell, capable of moving for a considerable distance along the edges of rocks by means of its flat foot in quest of food. It is primarily a vegetable feeder, subsisting mainly upon sea moss or algæ.

The animal is sexually mature at the age of 3 years when it reaches a diameter of from 80 to 90 millimeters. Apparently it grows slowly. The breeding season and the rate of growth of this species are not fully known.

AMOUNT AND VALUE

During the year 1927, the Philippine export of unmanufactured green snails to the United States, British East Indies, and Japan amounted to 4,037 kilograms valued at 2,230 pesos; during the year 1928, the total exportation was 11,666 kilograms valued at 2,423 pesos. While the amount of exported shells was practically trebled in 1928 the average price per kilogram was reduced to almost one-half.

The port of Zamboanga exported to Singapore 716 kilograms valued at 310 pesos, during 1928; 375 kilograms valued at 226 pesos, during 1929; and none during the first six months of 1930. From the port of Jolo there were exported to Sandakan and Singapore 2,598 kilograms valued at 1,287 pesos in 1928, and 3,408 kilograms valued at 1,740 pesos in 1929, but none from January 1 to June 30, 1930. Legaspi and Iloilo had no exportation of button shells during the years 1928, 1929, and

the first half of 1930. Since its opening in 1926 to July, 1930, the port of Davao had only one exportation of button shells, and that was on May 12, 1930, when 127.5 kilograms were shipped to Yap in the South Sea Islands. In 1928, the port of Cebu exported to London 63 cases of common shells valued at 2,500 pesos, but none during 1929 and the first seven months of 1930.

Generally these shells are taken from the fisheries near the respective ports of entry. Green snails obtained in the waters of southern Mindanao and of the Sulu Archipelago are entered either at Jolo or Zamboanga whence they are reshipped to Sandakan, Singapore, China, Japan, or Manila. Cebu is the port of entry for button shells originating from Bantayan, Bohol, and other neighboring places. Shells from Mindoro, Pangasinan, Aparri, and Tayabas are brought to Manila where they are utilized locally.

The price of the shells is primarily dependent upon the market fluctuations and varies with the quality and assortment. At present (1930) shells of good quality and without defects bring from 30 to 55 centavos per kilogram in Manila.

UTILIZATION

In Scandinavia the green snails for centuries were utilized as royal drinking cups. The shells were fashioned, polished, silver-mounted, and set with precious jewels. They are, however, no longer used as such nowadays, but many of them may be seen in cabinets kept there for sentimental reasons.

The principal use of green snails is for button making. But the thick pearly shell of this species has also found use in the manufacture of an infinite variety of articles such as spoons, forks, buckles for belts and shoes, handles for toilet objects, knives, opera glasses, and various instruments, inlays or decorations on fountain pens, desks, ink wells, clocks, picture frames, vanity cases, napkin rings, lamp shades, and many beautiful bric-a-brac. The Japanese and Chinese prepare the soft parts into tasty dishes. The Filipino fishermen utilize the meat extensively as food, and as a result, many shells that are otherwise valuable are rendered useless or cheap by the common practice of applying heat to extract the animal from the shell. Boiling or burning the hard substance injures the pearly luster. However, it is claimed that pouring boiling water on the shells does not destroy the luster and facilitates the removal of the animal, which can be easily pried out as it usually comes out of the shell upon being scalded. The shells can be satis-

factorily cleaned for industrial purposes by burying them in the ground for at least a month and then washing them in sea water.

WINDOW SHELL

Common names: Window shell, Chinese window shell, window oyster.

Local names: *Kapís* (Tag.), *lampirong* (Vis.), *kalampinay* (Bicol).

Scientific name: *Placuna placenta* Linnæus.

DESCRIPTION

Shell white, orbicular, rarely suborbicular, thin, pellucid, resembling somewhat a circular sheet of thin mica, foliaceous, valves compressed, flattened, margins rarely, if at all, subflexuous, marked with longitudinal striæ crossing concentric wavy lines, more or less wrinkled, representing stages of growth. Outside dull finish, inside silvery. Right valve flat, teeth unequal in length, diverging like the letter V. Left valve concave, with two divergent grooves corresponding to the teeth on the right valve, rayed with purple near the umbo.

Average of the short diameter of the large shells measured along the line bisecting the angle formed by the teeth, 12 to 14 centimeters; average thickness at the center of the flat valve, 1–1.5 millimeters.

DISTRIBUTION

The window shell occurs in certain definite localities in the Philippine Archipelago. Natural beds are found on the tide-flats at Parañaque, Binakayan, Kawit, and Samal, where the fisheries are extensive and rich, supporting an industry of considerable importance. The grounds in Bacoor Bay, doubtless the most productive, yield large crops regularly, while the Samal fisheries in Bataan, although potentially rich are too uncertain and occasional on account of the excessive sedimentation and freshening of the water during June, July, and August particularly, when the rainfall is at the maximum, affecting materially the seasonal produce. Productive placuna beds exist at Sual in Pangasinan; at Panglao and Talibon in Bohol; at Valladolid and Cadiz Viejo in Occidental Negros; on the eastern shores of Guimaras; at Oton and Leganes in Iloilo; on the northern coast of Capiz and on the eastern side of Masbate; at Matican and Lampinigan Island, near Isabela, Basilan; at Dungun in a little bay east of Buan Island, on the south side of Tawitawi group, Sulu.

HABITAT, HABITS, AND CULTIVATION

Although usually found in the littoral zone, window shells are known to live in water as deep as 40 meters. They appear to thrive only on mud or sand-mud bottoms in shallow salt-water bays or at entrances of estuaries, and they seem to be able to survive where there is a considerable flow of fresh water. Like the common edible oysters, they subsist mainly upon microscopic marine organisms, particularly diatoms. Except during the early stage when the larvæ float and drift with the current these bivalves do not move about but are nevertheless free and unattached, lying on the bottom on their convex, left side. They are not of the actively burrowing kind. Their foot is not used for locomotion nor for digging but it functions as an instrument to prevent the mud getting into the gills and other organs. The window-shell oysters, like all the other bivalves, breathe and feed simultaneously, their right valve being raised slightly above the level of the left valve when performing the double function.

In some mollusks both reproductive elements are produced by the same individual; but, in most, an individual is either male or female. The sex of a shell is not betrayed by any superficial characters and can only be determined by microscopical examination. In the window shell the sexes are separate; the eggs and sperm are cast into the water at spawning time and their meeting is entirely left to chance. The mature ova resemble the adult shell in form; the spermatozoa have rounded heads and exceedingly long delicate tails. The shellfish is extremely prolific, each mature female producing several thousand eggs. It is a periodic spawner. In Bacoar Bay it spawns in April and has been found to reach a short diameter of from 55 to 77 millimeters at the end of the first year, and of about 133 millimeters in two years. Its rate of growth is apparently fairly fast in the waters of Manila Bay. It matures in three years.

The natural supply of window shells in shallow waters is sufficiently large, and there is little likelihood of their ever becoming extinct and it would be impossible to deplete them as their habits and methods of propagation are such that the spat would in a very short time repopulate a fishery if it could be exhausted. In most of the fisheries around Manila Bay the fishermen find it unnecessary to dive for the shells since these can be secured by simply wading in shallow water during low tide and feeling about with the toes and fingers. At Samal,

however, divers equipped with a diving headgear collect shells in water from 5 to 10 meters deep. Eighty per cent of the shells gathered by divers in this locality are dead. These are usually found buried in the muddy bottom. The natural though catastrophic occurrence, namely, mud burial, is responsible for the sporadic yield of the beds in close proximity to streams and lowlands.

There are no laws specifically regulating the collection of these shells, as regards size and season; but it is believed that such legislation would be unnecessary since the fishermen realize that only large shells are of the greatest value and do not as a rule fish out small ones for the market. Fishing for "seeds" or undersized shells is done practically throughout the year but only for the purpose of transferring them to the private claims where they are left to grow until they attain marketable size. This is a common practice among the fishermen in Bacoar Bay in particular, and it is mainly by means of this transplantation method that the fishery has been successfully maintained since it conserves the stock by allowing large numbers to spawn at least once before they are harvested.

In Binakayan and Kawit a sort of artificial cultivation is carried on with considerable success. Along the shore line may be seen staked-off private claims the respective owners of which employ men to guard the property against poachers. These claims constitute the main source of the industry in the region, although in the deeper water there is a considerably large area of public ground from which shells of all sizes may be obtained. Small and half-grown shells are planted on the mud-flats that are not exposed at low tide. The relaid shells are allowed to grow until they become marketable; these are usually harvested a year after the planting, but when the demand is great or the owner is in need of cash the farms are fished out earlier, as early as five or six months after the transplantation. It is interesting to note that window-shell culture and oyster farming are so successfully carried on simultaneously in Binakayan and Kawit that pretty nearly all the oyster farms here are also devoted to the raising of window shells. It has been reported that a good oyster-window-shell farm yields as much as twice the revenue if the ground is planted only to oysters. This is a suggestion of practical importance to all rational oyster culturists. So far as known no such combination of farming is conducted in any other district outside of Bacoar Bay.

A large number of the residents of Kawit and Binakayan engage in window-shell fishing, gathering no less than 20,000 per week, during favorable weather. They collect large and small shells, but the small ones are transferred to private plots of from 100 to 200 square meters, in which they are allowed to grow for five to eight months; they are then marketable. The large shells are brought ashore in dugouts and carried in bamboo baskets to the cleaning premises.

The shells are first soaked in basins of fresh water to loosen the scales on the outer surface; the scales are then scraped off with a flat piece of metal, and the edges are smoothed by rubbing them against a rock or earthen jar. The shells are graded according to quality and size and placed in large bamboo baskets (batulan or canastro) each containing one laksa (10,000) valves. Women constitute the majority of the workers, and it is not very difficult for a woman to clean 2,000 shells in a day for which she generally receives from 1 to 1.50 pesos. The wages, of course, fluctuate according to the market price of the cleaned products.

THE INDUSTRY AND ITS POSSIBILITIES

The industry has been almost entirely under the control of Chinese. The native fishermen, with few exceptions, are contracted to deliver the cleaned products to Chinese dealers who usually advance money to be paid in shells at the price when the money was obtained. It is obvious that the Chinese have the upper hand in the transaction. This is a situation that is very difficult to remedy since the native fishermen do not have any way of disposing of their product in great quantities except through the foreign dealers. The lumber companies or construction firms, many of which are owned by Chinese, send out agents to deal with the natives who perforce accept the dictated quotations. Not until the Filipino fishermen learn to form a coöperative organization will they be able to demand reasonable prices for their products.

Quite recently, however, at the inception of shell shops here, managed by Americans, the native fishermen have been selling their raw products directly to the firms or through agents sent by them to the fishing centers to deal with the native gatherers.

Manila alone uses every year several million window shells in house construction and shell crafts. The demand is increasing; and as soon as the utility of this material is recognized abroad, especially in southern California and in other semi-

tropical or tropical countries where the most popular types of homes are the bungalows in which the window shell can be used with artistic effect, it is expected that the export trade will be greatly increased.

In 1927, the total export of unmanufactured window shells from the Philippines to the United States and Hongkong amounted to 552 kilograms valued at 40 pesos, and in 1928 the exportation totaled 612 kilograms valued at 320 pesos. The export for 1929, although not yet officially reported, is claimed to have increased three fold in quantity. Manufactured articles, such as lamp shades and other shell-crafts, exported to the United States, Great Britain, Belgium, Germany, China, British East Indies, Dutch East Indies and Hongkong were valued at 54,157 and 69,219 pesos for 1927 and 1928 respectively.

In trade the right valves are known as flat, the left valves as bent, and shells that square above 80 millimeters are classified as "head." The so-called "first flat" and "first bent" or simply "firsts" are shells that square from 75 to 80 millimeters; the "seconds" square from 70 to 75 millimeters; the "thirds" from 60 to 70 millimeters; and shells that square less than 60 millimeters are graded as "fourths."

In Manila the price of window shells varies from 3 to 20 pesos per thousand, depending upon the grade and upon supply and demand. Sometimes these shells bring as much as 30 pesos per thousand. In Binakayan, Kawit, and Samal uncleaned and cleaned shells are sold for from 2 to 12 pesos per thousand.

UTILIZATION

The Chinese have long utilized this shell instead of glass for window panes. In the Philippines, it has been used for this purpose for hundreds of years. The windows in some of the oldest churches in Manila, such as the St. Augustine, Recollect, Franciscan, and Jesuit churches, and in many of the old convents and churches in the provinces, are proof of the strength and durability of the shell. There is no question as to its beautiful effect, and its usefulness can easily be recognized in the various articles that are manufactured from it. Art and science find it remarkably adaptable for making shell-craft products, such as, paneling, concealed lighting systems, partitions, shades, lanterns, shields, screens, trays, place cards, picture frames, coasters, candle sticks, cake and fruit dishes, and innumerable other novelties for home and office. These articles are all hand made, plain and hand painted with beautiful designs and scenes.

Saddle oyster shells are also utilized in shell-craft but to a very limited extent. Two species enter into the supply of the raw material, namely, *Placuna papyracea* Lamarck and *Placuna sella* Lamarck. These shells are known in trade as *Rufo* shells. They have a natural tinted coloring and give a mellow translucent effect. Beautiful shades and shields are made from them.

CHAMBERED NAUTILUS

Common names: Chambered nautilus, pearly nautilus.

Local names: Lagang; layagan (Vis.).

Scientific name: *Nautilus pompilus* Linnæus.

DESCRIPTION

Shell discoidal, involute, smooth, imperforate, white, with wavy, rather broad, bands of reddish or yellowish brown at the posterior end. Umbilicus covered by a callous pearly deposit. Interior of shell divided into 30 to 35 chambers by concave partitions or septa, perforated in the middle by a small siphonic tube.

DISTRIBUTION

The chambered nautilus is a cuttle-fish of wide distribution in tropical seas. It occurs in large numbers in the Polynesian islands, particularly around the islands of New Hebrides and the Fiji group. In the Philippines it is chiefly abundant on the southern coast of Negros, in Tañon Strait, and around Bantayan and Cebu. It is also found in considerable quantity in Palawan, Cuyo, Basilan, Leyte, and Mindoro. Undoubtedly this species inhabits the rocky places around Lingayen Gulf and along the coast of Cagayan, Tayabas, Camarines Norte, Camarines Sur, and Mindanao. The most important grounds are on the southern coasts of Negros and at the north end of the channel between this island and Cebu.

LIFE-HISTORY AND HABITS

The pearly nautilus is a natural coral-bottom dweller, crawling on the rocky floor of the sea where it procures its food among its abyssal associates. It is carnivorous and subsists mainly upon crabs and lobsters, which it hunts among the coral rocks. When crawling on the bottom its natural position is with the head downwards and the shell, accordingly, uppermost; when floating it swims backwards, with the shell foremost; a portion of the top of the shell is exposed; the animal is under water. It moves with a succession of jerks, after the manner of all cephalopods, due to the expulsion of water

from the siphon tube. When alarmed or disturbed it executes a sort of quick darting movement as it shoots water through its siphon more or less violently.

The mantle secretes the pearly floor of the cavernous outer or body chamber and adds new growth to the shell at the edge. As the nautilus grows, its shell becomes discoidal in form due to the effect of the animal's natural position while crawling on the rocky sea bottom. Periodically, as growth continues, the body of the animal is drawn forward and the muscle of attachment lowers itself to a certain interval where a pearly concave cell wall or septum is constructed. The muscular ligament grows only in front and wears off behind and always moves forward, except during the period of formation of each partition. The frequency of septum construction and the rapidity of the process are not known. The septa gradually increase in size and number and eventually a series of air cells is built. Specimens of about 110 millimeters in diameter when cut in sagittal section have been found to contain thirty-three septa. Passing through the center of each of these is the siphuncle, a membranous extension of the body connecting the innermost cell with the spacious body chamber. The thin hoselike membrane is supported and protected by a short calcareous tubular prolongation at each hole, and by means of this siphonic tube air is conveyed to the chambers. Analysis shows that this air is richer in nitrogen than the atmosphere. It therefore increases the buoyancy of the chambers sufficiently to enable the nautilus to maintain the relative weight of its growing body and its shell in water.

The sexes of this species are separate. The male products are introduced into the mantle cavity of the female by one of the arms of the male. This arm is especially modified as an intromittent organ and is called the hectocotylus arm. Fertilization and subsequent early processes in the development of the young are carried on in the body of the mother. The resulting offspring are called "polyps" and resemble the parents in all particulars. Nothing precise is known as regards the age and size at which this species is sexually mature, nor the length of its normal life.

As previously pointed out, the most important fisheries are on the southern coast of Negros, in Tañon Strait, and around Bantayan Islands. It has been stated that great numbers of nautili are obtainable along the southern shores of Negros Island at depths of between 400 and 600 meters and that they are

captured in deep-sea bamboo traps known as *bobos*. That the nautilus can thrive in water about 650 meters deep, there is no question; but it is rather doubtful whether or not this mollusk can be collected in water between 400 and 600 meters in depth off the southern coasts of Negros. In the first place, these depths are beyond the coral zone; coral reefs, the natural habitat of the nautilus, are in water that is less than 75 meters. In the second place, the so-called deep-sea bobos are usually set in water of not more than 60 meters in depth.

At present there is no systematic nautilus fishing in Philippine waters. The taking of this mollusk is only incidental, although the way it is caught may be regarded as fairly efficient and can be used for commercial purposes. Attracted by the smell of the bait, the nautilus enters the traps that are primarily set to capture bottom fish and crustaceans in deep waters. The mollusk as a catch is, therefore, only a by-product of a kind of deep-sea fishing in the Philippines. A considerable number of empty shells may be gathered from the shallow places and beaches of rich fishing grounds.

The chambered nautilus occurs abundantly in the Visayas during the summer, and fishing is usually most brisk in the month of June. The mollusk is trapped by large bamboo cages (*bobos*). These are generally rectangular or heart-shaped and operate on the principle of a rat-trap. They may have an entrance above, on the side, or at the end. The aperture is a funnel of sharp-pointed slats directed inwards, so as to allow the entry of the animal but preclude its escape. For the removal of the catch there is provided a sort of trap door usually located on the side or in the bottom. Each trap is weighted with stones, baited with cooked or partially spoiled crab or crayfish, and provided with a warp or lift rope to the free end of which is attached a bamboo float or buoy to indicate the location of the apparatus. Bait, which is particularly "high," that is, strongly scented, has been found very effective in attracting the nautilus through its sense of smell, which is apparently keener than its sense of sight. The smelly potage is usually wrapped in coconut fiber like a small parcel and then placed in the trap. The baited contraption is lowered to the bottom and left there for a period of several hours before hauling it up. Daily hauls are usually the practice.

In other regions the modes of capturing this animal for the embers or for the pot are quite interesting. In the South Sea Islands where the mollusk occurs in great abundance, skin

diving and trapping are the most common methods. The islanders catch the animal with their native fish-falls or with spears and dipnets in waters from 4 to 7 meters in depth. The traps are baited with sea egg or sea urchin (*Echinus*). The Fijians use wicker-work traps not much different from the bobos in principle. The bait used is boiled crayfish. As soon as a nautilus is discovered clinging to some prominent ledge the fisherman gently lowers his trap near the animal. The gear is either watched closely until the quarry is entrapped or left there with a marker to be examined after a certain period. For removing the catch the Fijians use a sort of grapnel consisting of a small piece of branched wood with the branches sharpened. A perforated stone as sinker is attached to the tool. This is lowered and passed through the opening on top of the trap until the pointed branches reach the animal. By a skillful manipulation the fisherman hooks his victim and hoists it safely into his dugout.

UTILIZATION

The nautilus has economic uses. The animal is eaten as a soup meat, boiled, or roasted. If properly prepared, the dried flesh would make an agreeable viand. The shell is now being used extensively in the manufacture of ornamental objects. The mother-of-pearl luster of the inside surface is very attractive for decorative purposes or inlays. Lamp shades, vases, dippers, and spoons are made of the shells. These are also used in making cameos. The local demand for nautilus shells is increasing. Shell shops are being established in Manila, and manufactured articles from sea shells have an increasing local trade. Chinese in the Philippines buy the shells, accumulating them for export to China where they are manufactured into buttons. Export to the United States or Europe is very limited.

ILLUSTRATIONS

PLATE 1

Philippine gold-lip pearl shell, *Pinctada maxima* (Jameson).

PLATE 2

Philippine black-lip pearl shell, *Pinctada margaritifera* (Linnæus).

PLATE 3

FIG. 1. Blanks marked off by tubular saw on shell of black-lip, *Pinctada margaritifera* (Linnæus).

2. Blanks marked off by tubular saw on shell of gold-lip, *Pinctada maxima* (Jameson).

PLATE 4

FIG. 1. Blanks cut from shell of gold-lip, *Pinctada maxima* (Jameson).

2. Blanks and finished buttons from shell of gold-lip, *Pinctada maxima* (Jameson).

PLATE 5

FIG. 1. Trocha shell, *Trochus niloticus* Linnæus var. *maximus* Koch.

2. Trocha shell, *Trochus niloticus* Linnæus.

PLATE 6

FIG. 1. Trocha shell, *Trochus noduliferus* Lamarck.

2. Trocha shell, *Trochus obeliscus* Gmelin.

PLATE 7

FIG. 1. Trocha shell, *Trochus niloticus* Linnæus; showing cuts for buttons.

2. Trocha shell, *Trochus niloticus* Linnæus; showing characteristic markings.

PLATE 8

Green snail, or turban shell, *Turbo marmoratus* Linnæus.

PLATE 9

FIG. 1. Green-snail powder boxes and hair-pin cup. (Courtesy of Philippine Shell-Craft Corporation.)

2. Green-snail buckles. (Courtesy of Philippine Shell-Craft Corporation.)

3. Green-snail table, or reading, lamp. (Courtesy of Philippine Shell-Craft Corporation.)

4. Green-snail desk lamp with narra base. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 10

Kapis, or window shell, *Placuna* (*Placenta*) *placenta* Linnæus; showing four commercial grades.

PLATE 11

- FIG. 1. Shell windows in the Episcopal Cathedral, Ermita, Manila.
2. Shell windows in the Philippine General Hospital, Manila.

PLATE 12

Screen made of window shell and red narra.

PLATE 13

Various forms of panels made of window shell. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 14

- FIG. 1. Kapis lantern of fanciful design. (Courtesy of Philippine Shell-Craft Corporation.)
2. Kapis lantern of modernistic design. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 15

- FIG. 1. Kapis inverted shade of modernistic design. (Courtesy of Philippine Shell-Craft Corporation.)
2. Kapis special inverted shade. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 16

Four types of table lamps made from window shell. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 17

Completely set dining table with various novelties from window and pearl shells and green snail. (Courtesy of Philippine Shell-Craft Corporation.)

PLATE 18

- FIG. 1. Shields made of rufo shell, or saddle oyster shell, *Placuna (Placenta) sella* Gmelin. (Courtesy of Philippine Shell-Craft Corporation.)
2. Direct rufo shade. (Courtesy of Philippine Shell-Craft Corporation.)



PLATE 1.



PLATE 2.

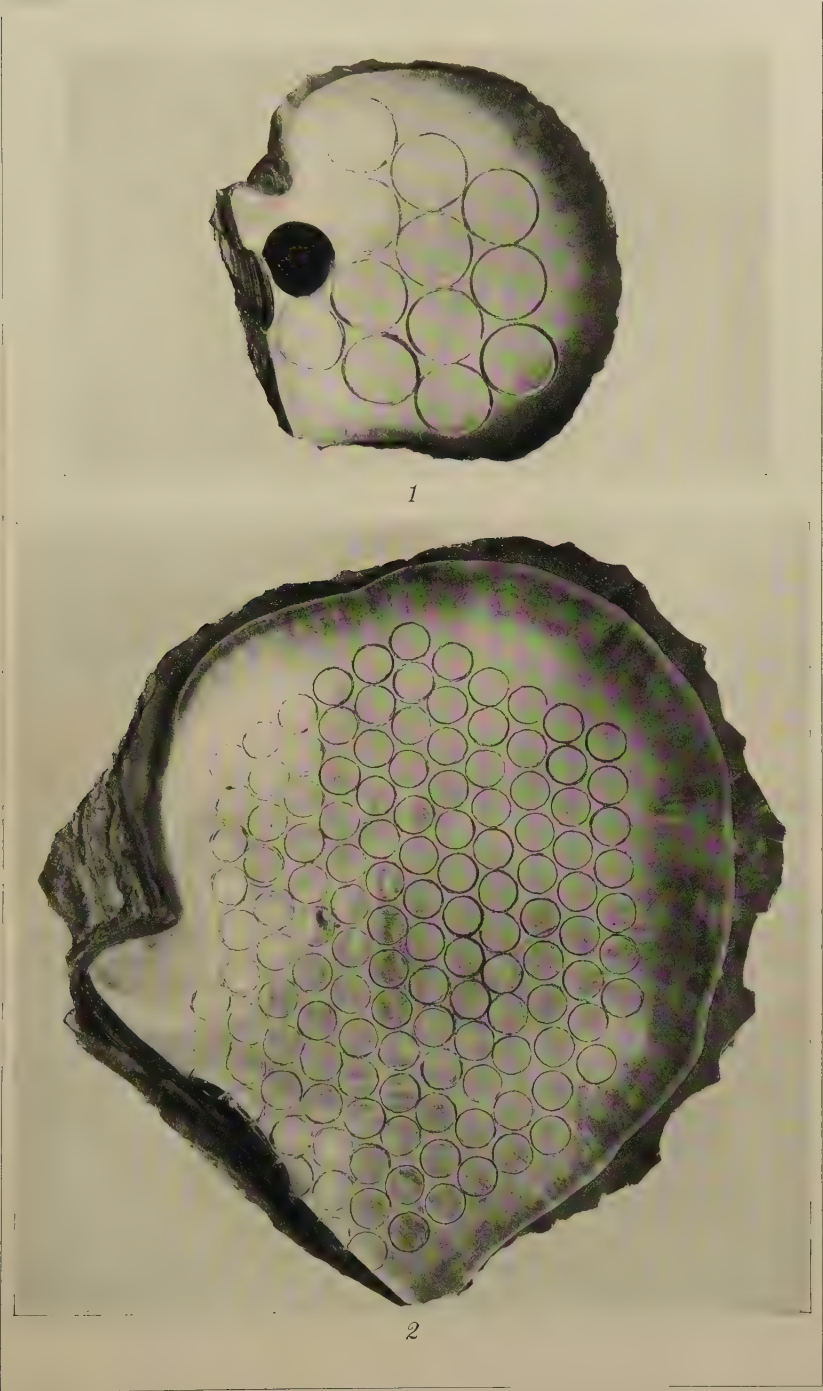
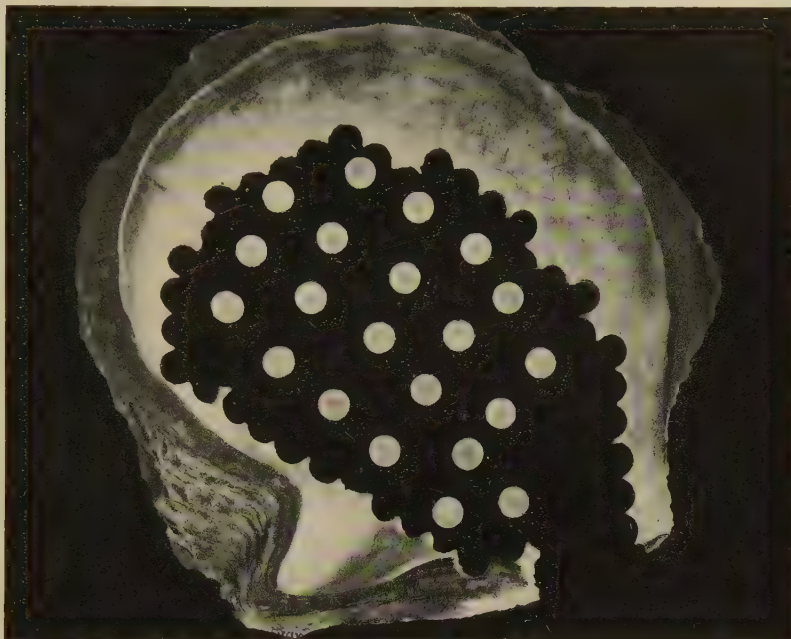
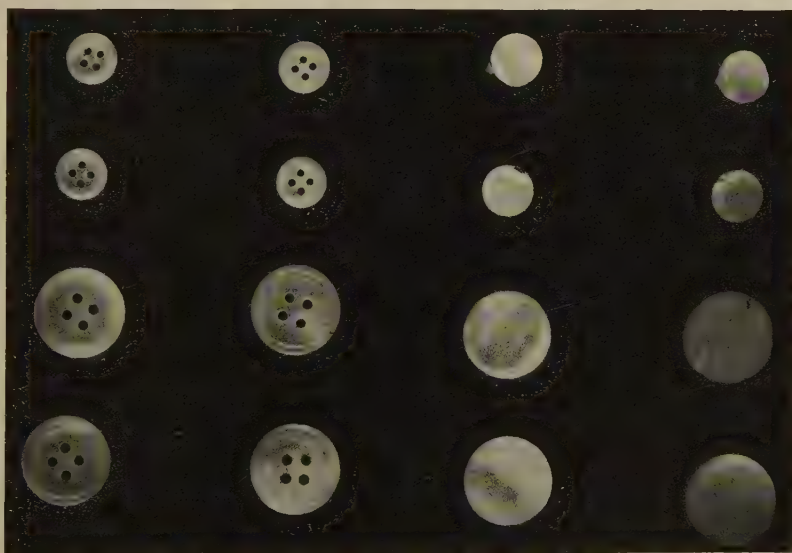


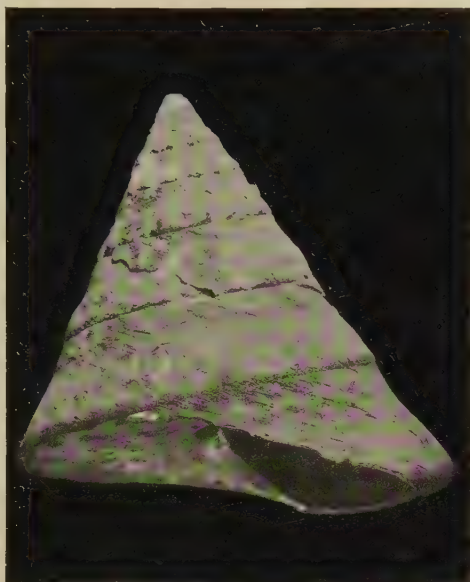
PLATE 3.



1



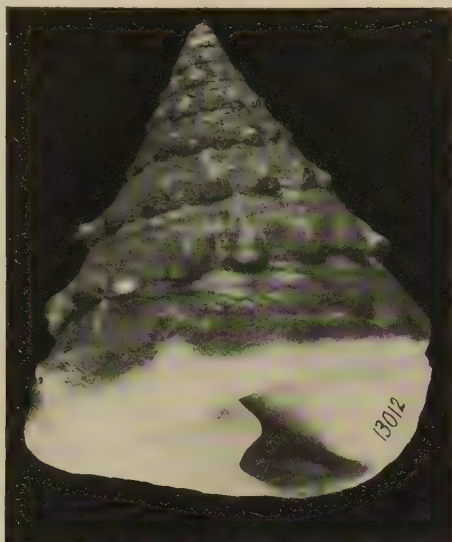
2



1



2



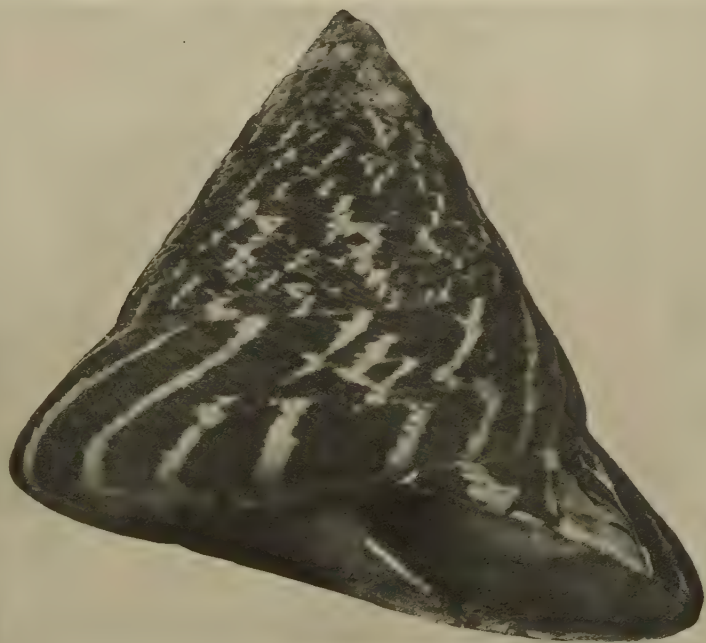
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2



1



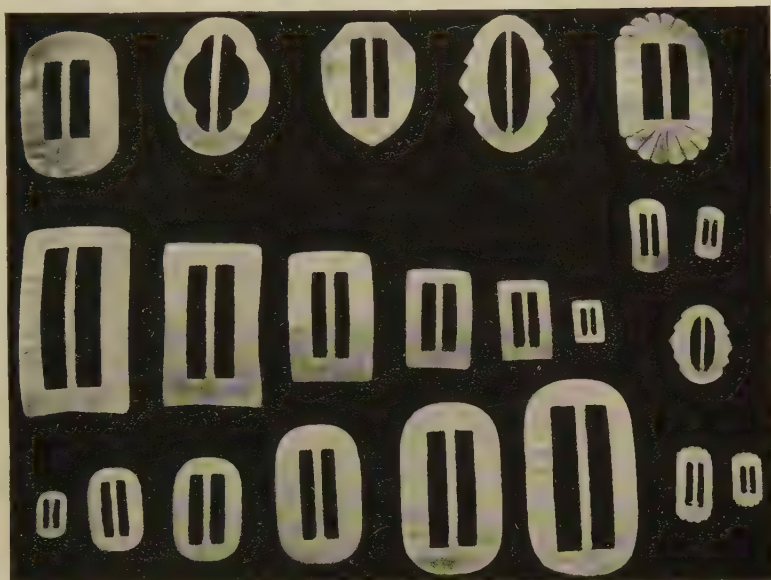
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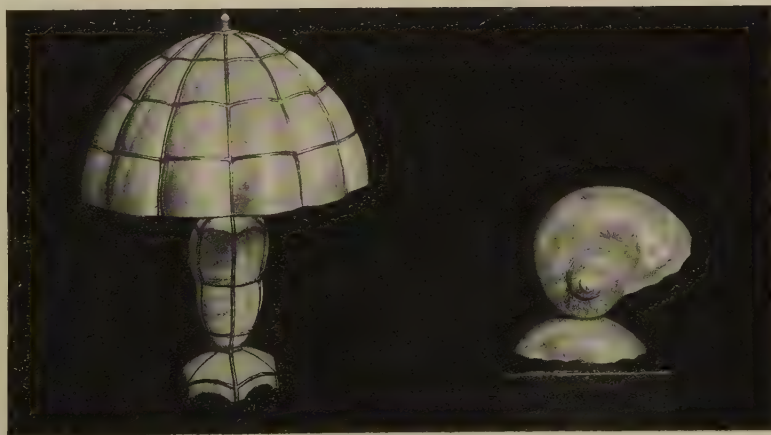
PLATE 8.



1



2



3

4

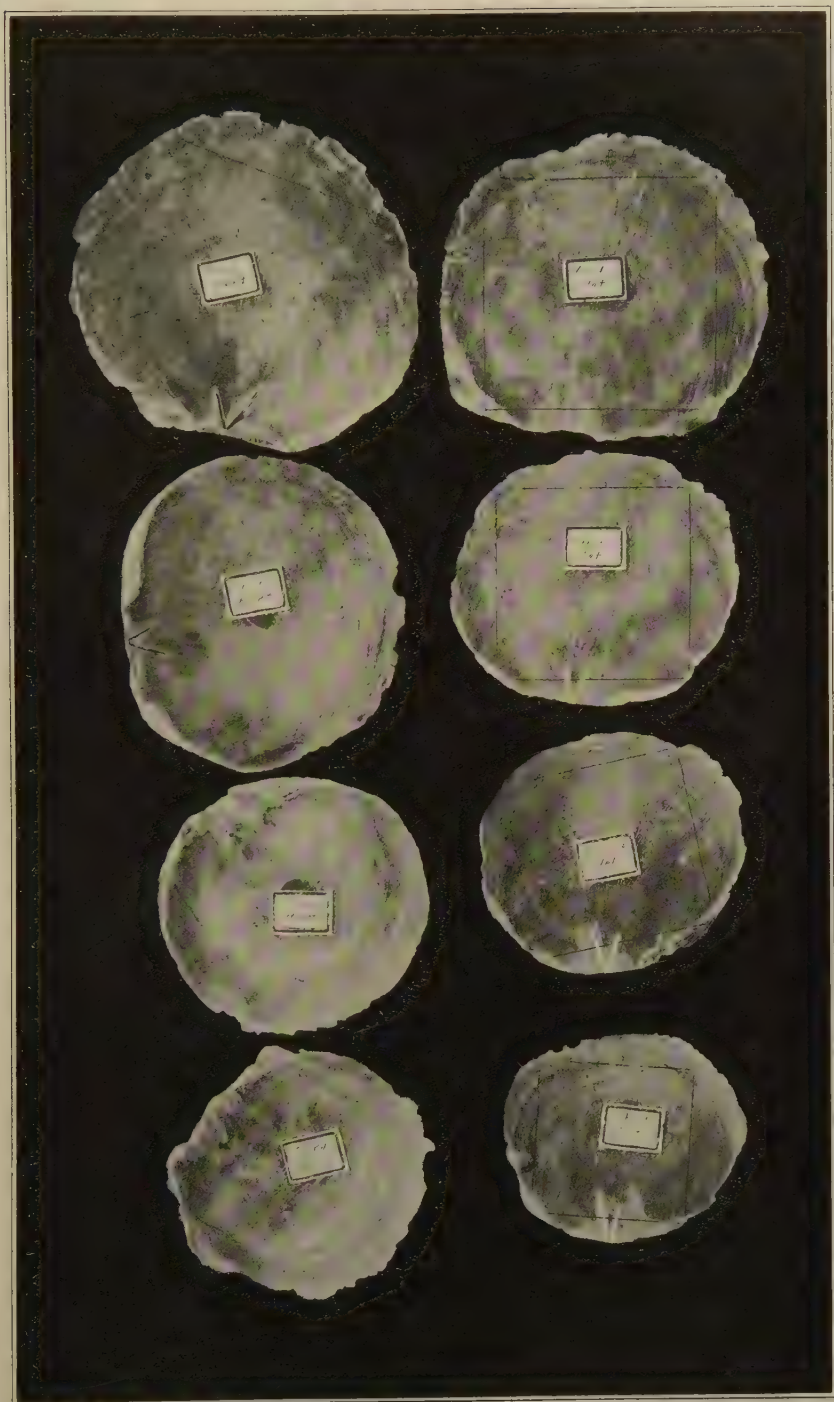
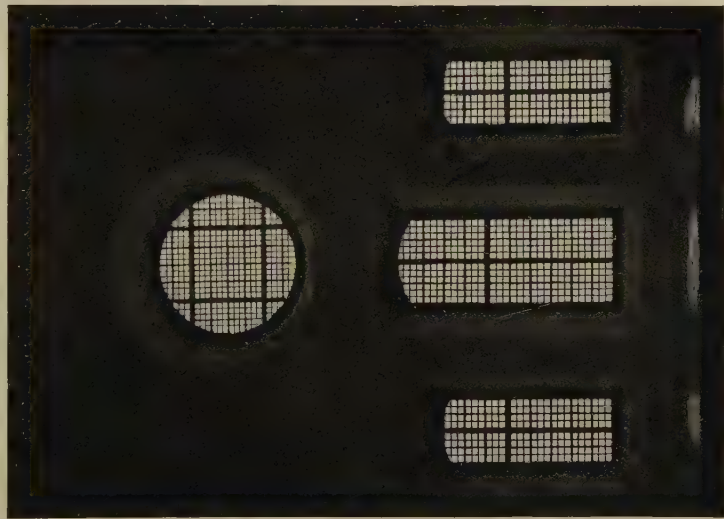
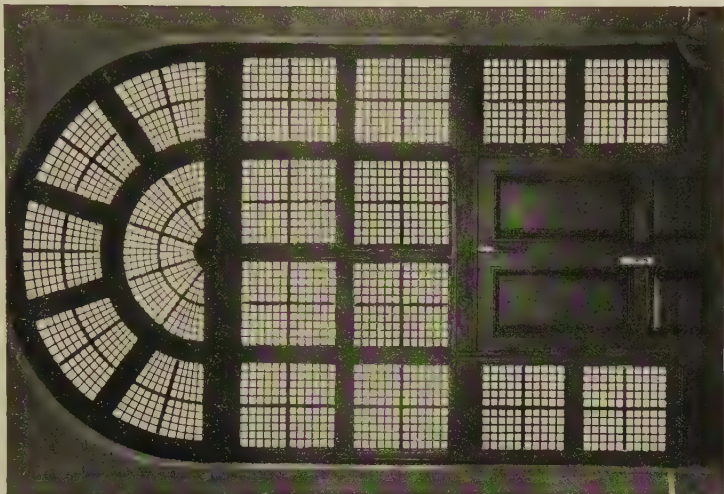


PLATE 10.



1



2

PLATE 11.

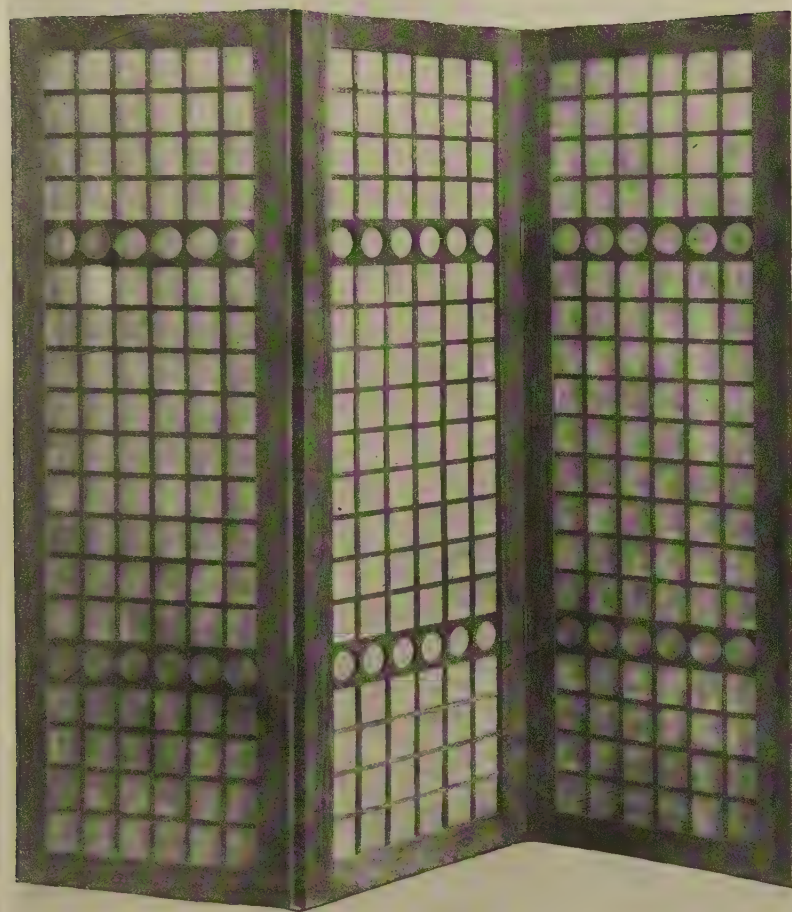


PLATE 12.

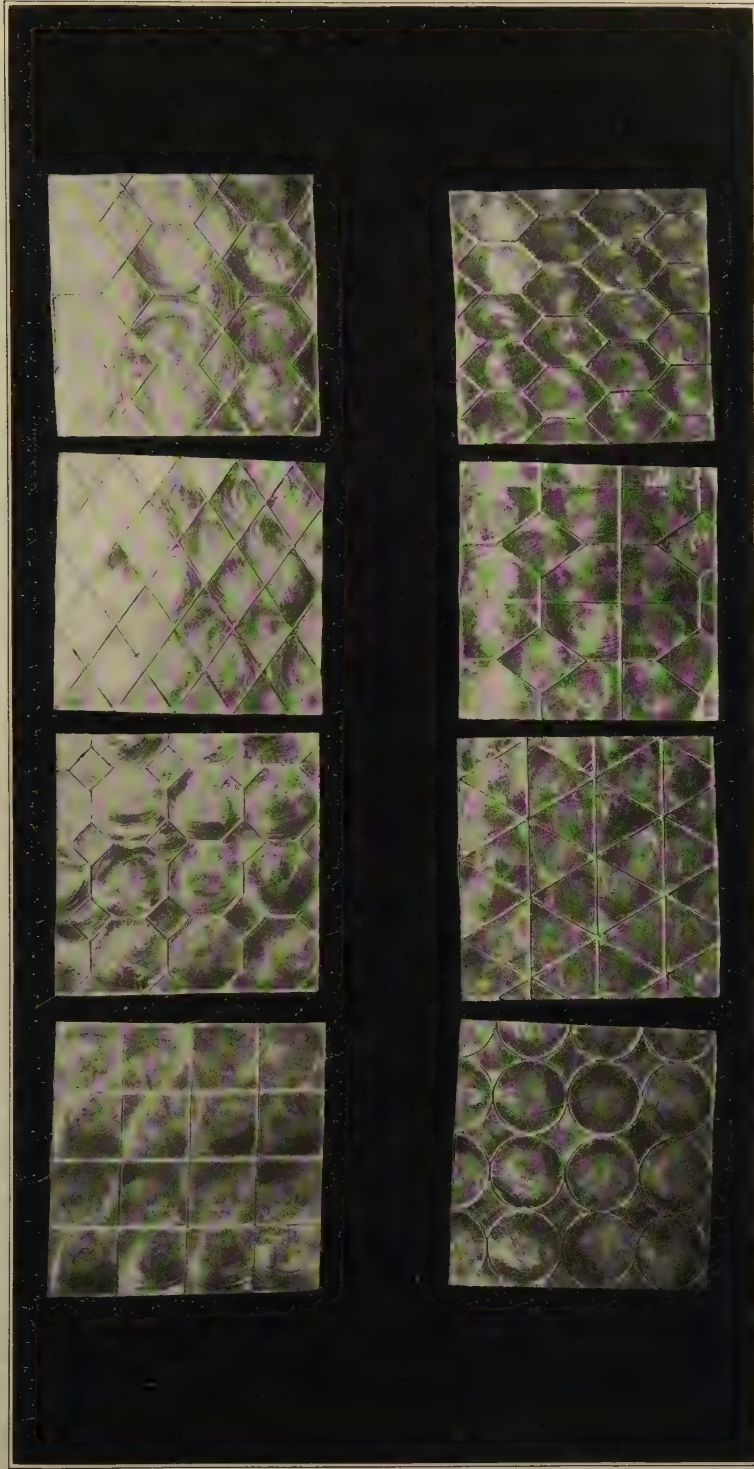


PLATE 13.

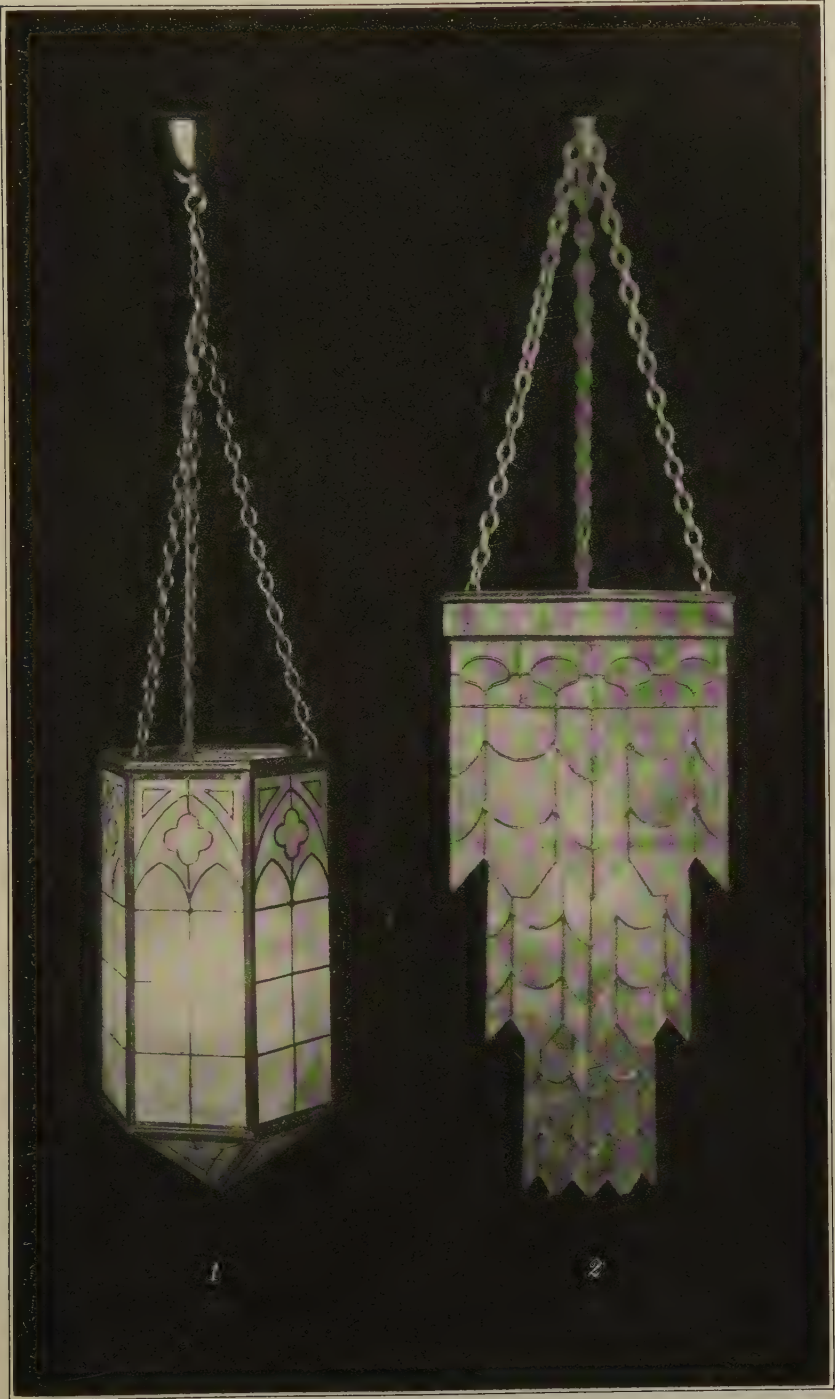


PLATE 14.

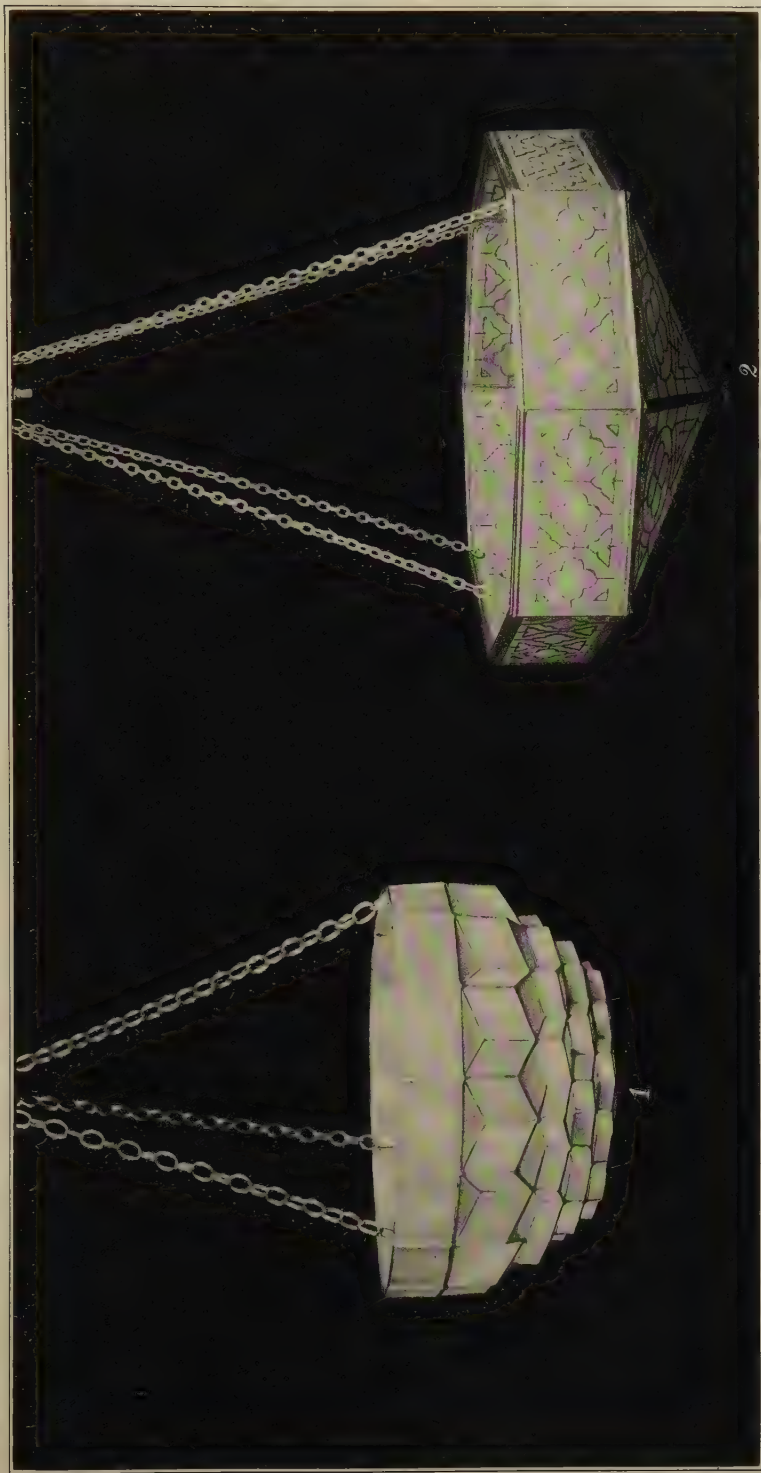


PLATE 15.

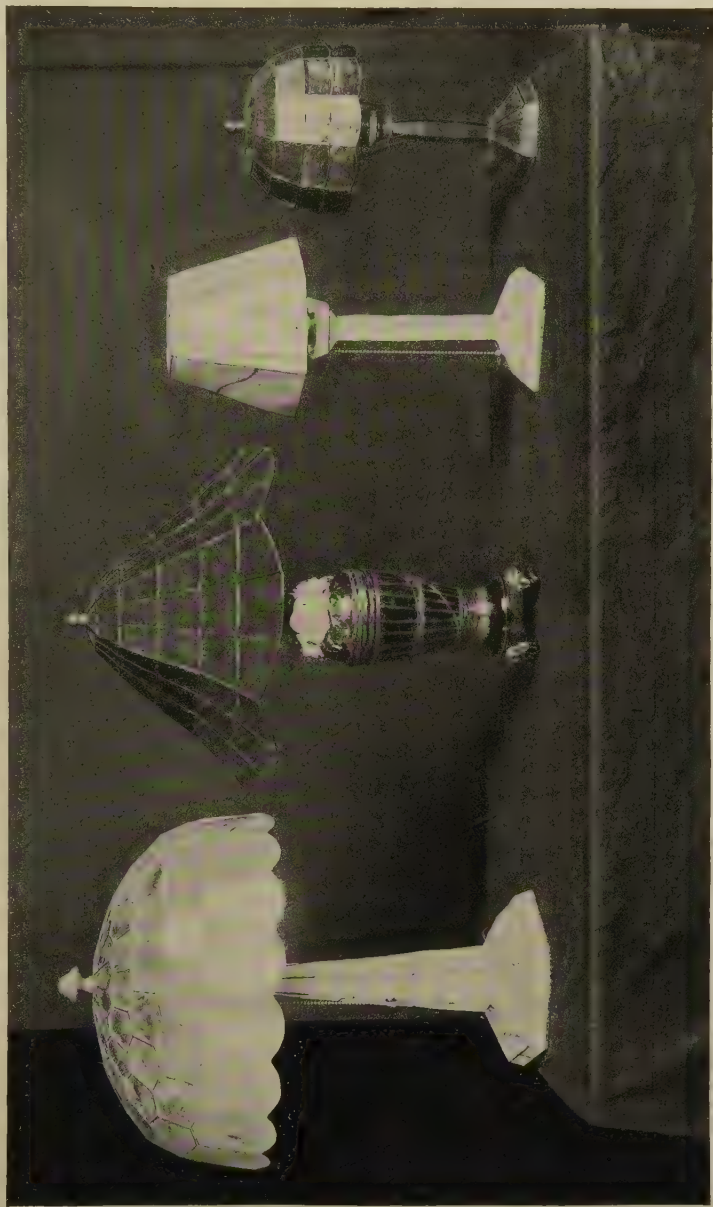
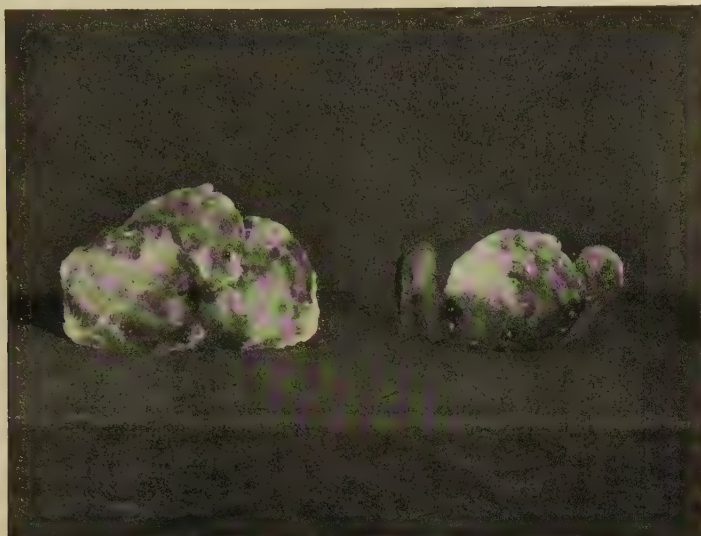


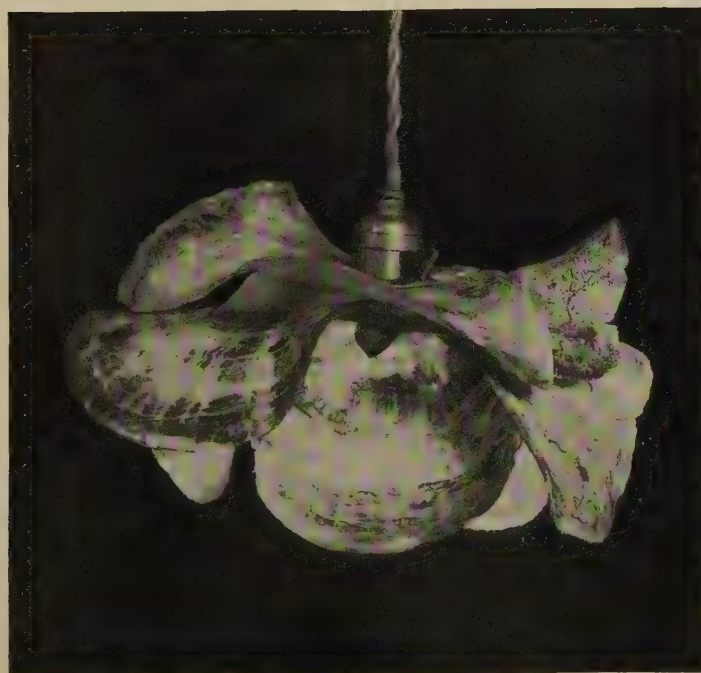
PLATE 16.



PLATE 17.



1



2

A NEW PARASITE OF PHILIPPINE AMPHIBIA¹

By A. C. WALTON

Of Knox College, Galesburg, Illinois

ONE TEXT FIGURE

During the examination of a lot of *Oxysomatium* material obtained from amphibian hosts, attention was drawn to a species that seemed specific to a Philippine frog, *Rana magna* (?), and that differed distinctly from any species of that genus yet reported from Oriental amphibian hosts.²

The body proportions of the two sexes are usually differentiated, the male being relatively slender for its length and the female relatively stout. Both sexes taper gradually cephalad; caudad they taper gradually to the anal region and then rather abruptly to a very marked spikelike extension of the tail. The three lips are low and very poorly differentiated, each showing a pair of indistinct papillæ. No trace of buccal armature is distinguishable. The pharyngeal musculature is well set off from that of the œsophagus. The latter terminates in a distinct bulbar enlargement, showing an anteriorly flaring neck at the point of attachment to the œsophagus. Distinctly chitinized cutting plates are present in the bulbar region. The bulbar canal opens through flaplike valves into the dilatated anterior end of the intestine. The excretory pore opens slightly anterior to the neck of the œsophageal bulb. The posterior end of the male bends sharply ventrad and shows six pairs of preanal, two pairs of adanal, and two (three) pairs of postanal sessile papillæ; a rather unusual placing of the caudal papillæ in members of the genus *Oxysomatium*. The spicules are subequal, simple, and short. The accessory piece is well chitinized, though very small. The vulva opens slightly cephalad of the middle of the body. The muscular ovejector is "S"-shaped, passing cephalad before dividing into its two divergent branches. The eggs contain well-differentiated larvæ while still in the uteri. This species is probably oviparous, the larvæ hatching soon after oviposition.

¹ Contribution from the Knox College Biological Laboratories, No. 33.

² Morishita, K., Journ. Fac. Sci. Imp. Univ. Tokyo, Sec. IV 1 (1926) 1-32, pls. 1-5.

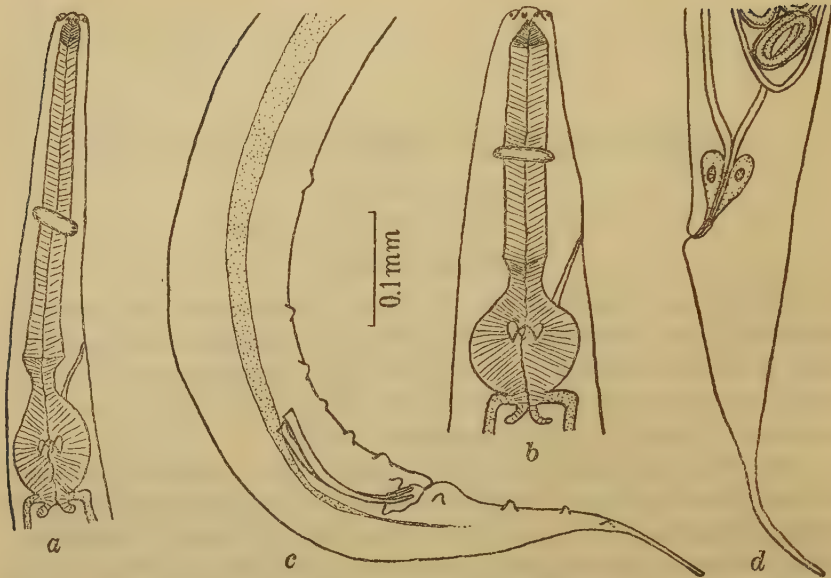


FIG. 1. *Oxysomatium ranæ* sp. nov.; a, male, anterior end, dorsal aspect; b, female, anterior end, dorsal aspect; c, male posterior end, lateral aspect; d, female, posterior end, lateral aspect. All figures are to the same scale. (Drawing by Walton.)

AVERAGE MEASUREMENTS

Male.—Body length, 2.5 millimeters; greatest width, 0.086; length of pharynx, 0.035; length of œsophagus, excluding bulb, 0.34; bulb, 0.055 by 0.065; nerve ring, 0.225 millimeter from the lips; excretory pore, 0.36 millimeter from the lips; cloaca-tail distance, 0.225; spicules, 0.16; accessory piece, 0.025; length of caudal spike, 0.09.

Female.—Body length, 3.8 millimeters; width at vulva, 0.23; length of pharynx, 0.03; length of œsophagus, excluding bulb, 0.265; bulb, 0.065 by 0.085; nerve ring, 0.15 millimeter from the lips; excretory pore, 0.28 millimeter from the lips; vulva-anus distance, 2; anus-tail distance, 0.23; length of caudal spike, 0.1; embryonated eggs, 0.056 by 0.076.

This hitherto undescribed species taken from the intestines of specimens of *Rana magna* (?), a Philippine frog, is here named *Oxysomatium ranæ* sp. nov.

The type specimens are in the collection of Dr. H. B. Ward, University of Illinois, Urbana, Illinois.

ILLUSTRATION

TEXT FIG. 1. *Oxysomatium ranæ* sp. nov.; *a*, male anterior end, dorsal aspect; *b*, female, anterior end, dorsal aspect; *c*, male, posterior end, lateral aspect; *d*, female, posterior end, lateral aspect. All figures are to the same scale. (Drawings by Walton.)

THREE NEW SAND FLIES FROM THE PHILIPPINES¹

By C. MANALANG

Of the Philippine Health Service, Manila

THREE TEXT FIGURES

In March, 1930, three male recumbent-haired sand flies were caught in the vicinity of Bigti camp, Angat-Novaliches water project, Bulacan Province, Luzon. Potash preparation showed a bell- or pear-shaped pigmented area on the dorsal wall of the buccal cavity. In May three flies (two females and one male) with pigmented areas identical to those of the male from Bigti were sorted out of the flies sent from Malinao, Camarines Sur. In June a female was caught in Bigti with pigmented area of the same shape.

From the barrio of Dayap, Laguna, came a collection that contained a female with a mushroom-shaped pigmented area. Collections from Sipocot and Ragay, Camarines Sur, also showed a few females with the same shape of pigmented area but with wing veins and teeth somewhat similar to those of the female.

Towards the end of April, 1930, Dr. Vicente Torrechante, of the division of malaria control, sent me a large collection of sand flies from Sipocot, Camarines Sur Province, in which was found a female with a very dark funnel-shaped pigmented area. In his subsequent collection from Apali and Malinao of the same province, a male and a female with this type of pigmented area were also found.

The three species of sand flies are recumbent-haired while their males have the *minutus* type of genitalia. As far as I can find out, they possess a combination of characters different from those already described for sand flies from the Philippines and other Oriental countries. Therefore, I propose to name them *Phlebotomus bigtii*, *P. dayapensis*, and *P. torrechantei*. The following descriptions are based entirely on potash preparations mounted in Berlese's fluid. The spermatheca are not described because the preparations did not show them clearly.

¹From the field laboratory, division of malaria control, Philippine Health Service, Tungkong Manga, Bulacan.

PHLEBOTOMUS BIGTII sp. nov. Fig. 1.

FEMALE

A large species; body length, 2.85 to 2.95 millimeters; wings long, broad, and asymmetrical.

Palps.—First segment one-half the length of the second; third segment longer than the fourth; second and fourth segments about equal; the combined lengths of the second and third segments may be either slightly greater or less than the length of the fifth. Total length, 0.53 to 0.58 millimeter (fig. 1, e).

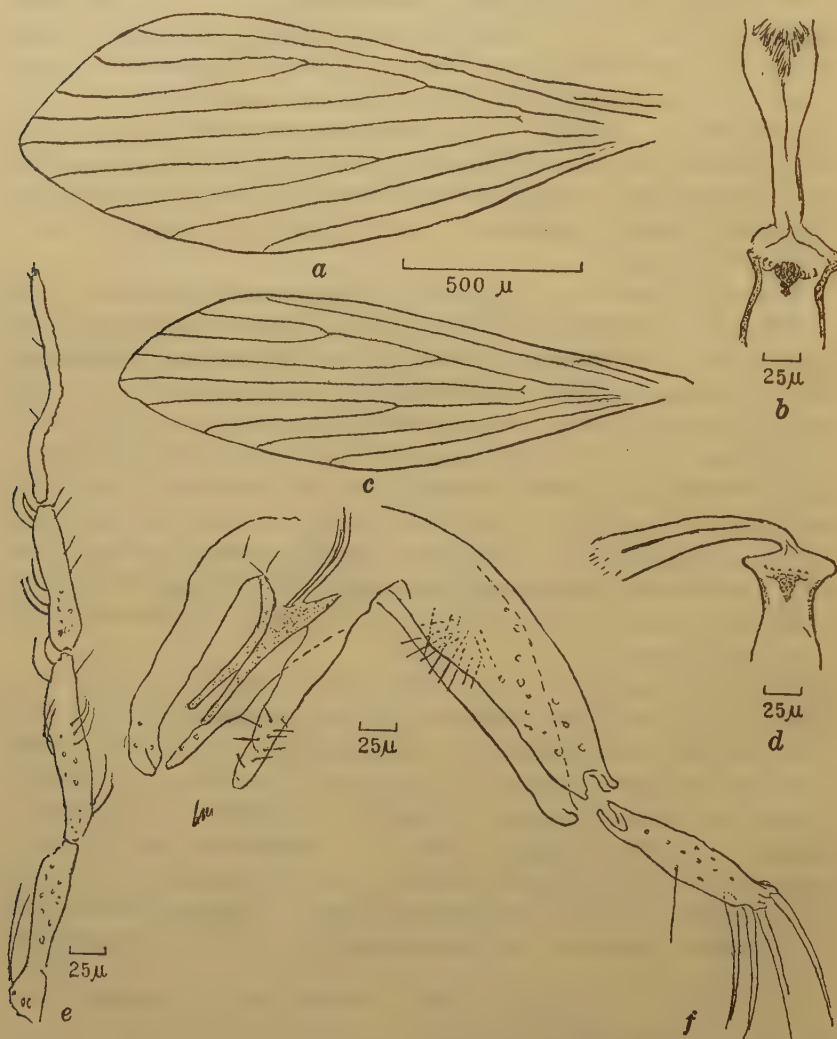


FIG. 1. *Phlebotomus bigtii* sp. nov.; a, wing, female; b, buccopharynx; c, wing, male; d, pharyngeal bulb; e, palps; f, genitalia.

Antennæ.—Incomplete and denuded in the two specimens examined.

Buccopharynx.—Buccal cavity with dark bell- or pear-shaped pigmented area. Armature with one row of ten to twelve long bent pointed teeth present. Pharyngeal bulb with a thick brush of spines (fig. 1, b).

TABLE 1.—Measurements of *Phlebotomus bigtii* sp. nov. in millimeters.

	Female 1.	Female 2.	Male 1.	Male 2.
Body:	mm.	mm.	mm.	mm.
Clypeus and head.....	0.300	0.350	0.275	0.300
Thorax.....	0.575	0.550	0.400	0.450
Abdomen.....	1.900	1.800	1.400	1.300
Superior clasper, segment 1.....	0.175	0.150	0.250	0.250
Total length.....	2.950	2.850	2.325	2.300
Labium.....	0.280	0.250	0.175	0.200
Antenna:				
Segment III.....	0.350	0.350	0.400	0.400
Segment IV.....	0.137	0.150	0.175	0.175
Segment V.....	0.137	0.150	0.175	0.175
Segment VI.....	0.137	0.150	0.175	0.175
Segments XII to XVI.....			0.425	0.450
Segments I, II, and VII to XI.....		0.900	1.000	1.000
Total length.....			2.350	2.375
Palp:				
Segment 1.....	0.050	0.050	0.037	0.025
Segment 2.....	0.100	0.100	0.087	0.087
Segment 3.....	0.125	0.125	0.112	0.112
Segment 4.....	0.112	0.100	0.100	0.112
Segment 5.....	0.250	0.212	0.225	0.237
Total length.....	0.637	0.587	0.561	0.603
Wing:				
Length.....	1.900	2.000	1.700	1.700
Width.....	0.650	0.650	0.450	0.500
Hind leg:				
Femur.....	0.760	0.800	0.650	0.700
Tibia.....	1.400	1.425	1.230	1.350
Tarsus segment 1.....	0.725	0.725	0.650	0.700
Tarsi 2 to 5.....	0.800	0.800	0.700	0.750
Total length ^a	3.685	3.750	3.230	3.500
Superior clasper, male:				
Segment 1.....			0.250	0.250
Segment 2.....			0.112	0.125
Intromittent organ.....			0.087	0.087

^a Not including coxa and trochanter.

Thorax and abdomen.—No scales on the pleuræ. Hairs erect on the dorsum of the thorax and first abdominal segment but recumbent on the other segments.

Wings.—Voluminous, with the anterior border slightly more curved than the posterior. Relative lengths of important veins

vary in different individuals but α is conspicuously long, being slightly shorter only than the combined lengths of β or γ or $2 \times \beta$ while δ is distinctly longer than either β or γ . Wing, 1.9 to 2 millimeters long, 0.65 millimeter wide (fig. 1, a).

Hind legs.—Total length 1.2 to 1.3 times the length of the body. Total length, 3.6 to 3.7 millimeters.

MALE

Smaller than the female, total body length, 2.3 millimeters; short geniculate spines visible in the antennal segments. Relative lengths of wing veins different from the female in that α is much shorter than $\beta + \gamma$ while δ is distinctly shorter than either β or γ (fig. 1, c). The buccal armature and pigmented area are similar to those of the female except that the teeth are fewer and shorter. The spines in the pharyngeal bulb are few and slender (fig. 1, d).

Genitalia.—Typical of the *minutus* group with four stout basally pigmented pointed macrochætæ, two apical and two subapical. Intromittent organ paired; genital filaments not protruding (fig. 1, f).

PHLEBOTOMUS DAYAPENSIS sp. nov. Fig. 2.

FEMALE

A medium-sized species, 2.15 to 2.25 millimeters long; wings symmetrically lanceolate.

Palps.—First segment about one-half or more the length of the second; the third equal to the combined lengths of the first and second; fourth segment longer than the third; fifth segment about equal to the combined lengths of the second, third, and fourth segments in one female but shorter than the third and fourth in another. Total length, 0.66 to 0.74 millimeter (fig. 2, e).

Antennæ.—Segment III 2.5 times segment IV and shorter than the combined lengths of segments XII to XVI. Short geniculate spines are present.

Buccopharynx.—Buccal cavity with mushroom-shaped pigmented area. Teeth number 24, more or less, their points numerous and like the teeth of a saw. Pharyngeal bulb long; flask-shaped, without armature at its œsophageal extremity (fig. 2, b).

Thorax and abdomen.—Similar to the preceding species. Total body length including clypeus, 2.15 to 2.25 millimeters.

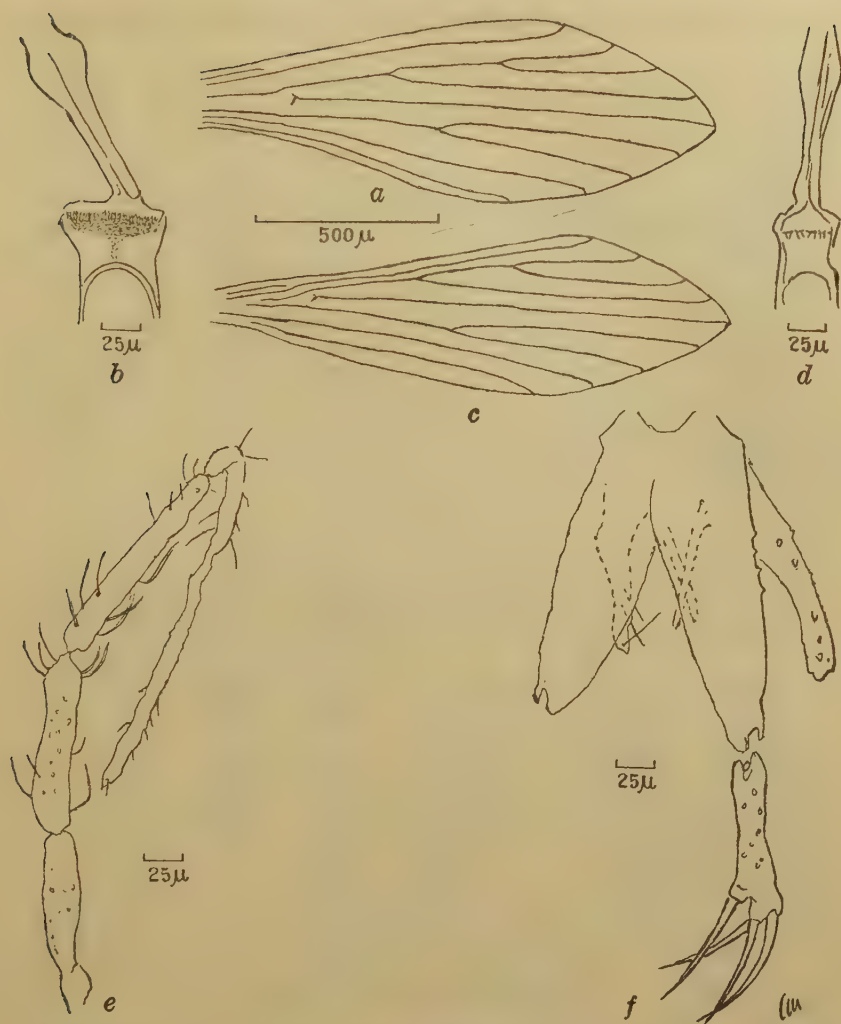


FIG. 2. *Phlebotomus dayapensis* sp. nov.; a, wing, female; b, buccopharynx; c, wing, male; d, pharyngeal bulb; e, palps; f, genitalia.

Wings.—Anterior and posterior curvatures alike. Relative length of important veins are: $a = \beta$; a or $\beta = 2 \times \delta$; $\gamma > \beta$.

Hind legs.—Total length, 1.1 to 1.2 times the total length of the body. Total length is 2.5 to 2.6 millimeters.

MALE

Smaller than female; antennæ longer with longer geniculate spines; palps distinctly shorter. Wing veins are as follows: a longer than β ; β , γ , and δ are all about equal. Buccal armature

TABLE 2.—*Measurement of Phlebotomus dayapensis* sp. nov. in millimeters.

	Female 1.	Female 2.	Male 1.	Male 2.
	mm.	mm.	mm.	mm.
Body:				
Clypeus and head.....	0.300	0.275	0.300	0.300
Thorax.....	0.500	0.500	0.400	0.400
Abdomen.....	1.000	1.350	1.100	1.100
Superior clasper segment 1.....	0.150	0.130	0.237	0.250
Total length.....	2.150	2.255	2.037	2.050
Labium.....	0.200	0.200	0.125	0.175
Antenna:				
Segment III.....	0.250	0.250	0.300	0.300
Segment IV.....	0.100	0.100	0.125	0.125
Segment V.....	0.100	0.100	0.125	0.125
Segment VI.....	0.100	0.100	0.125	0.125
Segment XII to XVI.....		0.325		0.350
Segments I, II, and VII to XI.....		0.637	0.750	0.750
Total length.....		1.512		1.775
Palp:				
Segment 1.....	0.037	0.050	0.037	0.025
Segment 2.....	0.075	0.075	0.075	0.066
Segment 3.....	0.125	0.125	0.087	0.091
Segment 4.....	0.158	0.160	0.087	0.075
Segment 5.....	0.350	0.250	0.175	0.150
Total length.....	0.745	0.660	0.461	0.417
Wing:				
Length.....	1.600	1.600	1.550	1.400
Width.....	0.460	0.460	0.450	0.425
Hind leg:				
Femur.....	0.630	0.650	0.650	0.600
Tibia.....	0.950	0.900	1.100	0.925
Tarsus segment 1.....	0.450	0.425	0.560	0.500
Tarsi segments 2 to 5.....	0.600	0.550	0.600	0.600
Total length ^a	2.630	2.525	2.910	2.625
Superior clasper, male:				
Segment 1.....			0.237	0.250
Segment 2.....			0.100	0.100
Intromittent organ.....			0.087	0.087

^a Not including coxa and trochanter.

without pigmented area, with fewer, broader, and less-pointed teeth than those in the female (fig. 2, *d*).

Genitalia.—Similar to the preceding species. The distal segment of the superior clasper is armed with four nonpigmented, pointed macrochætæ, three apical and one subapical (fig 2, *f*).

The wing venation and pigmented area in the buccal cavity of this species are similar to those of *P. taianensis* Patton and Hindle,² but the morphology and arrangement of the macrochætæ of the male terminalia are different. *Phlebotomus taianensis* has more than twice as many teeth in the buccal cavity.

² Proc. Royal Soc. Sec. B 102 (1928) 533-551.

PHLEBOTOMUS TORRECHANTEI sp. nov. Fig. 3.

FEMALE

Medium sized, the body measuring 2.4 millimeters. Wings voluminous and almost symmetrical; antennæ and legs relatively long.

Palps.—Second segment twice the length of the first; fourth segment longer than the second but slightly shorter than the

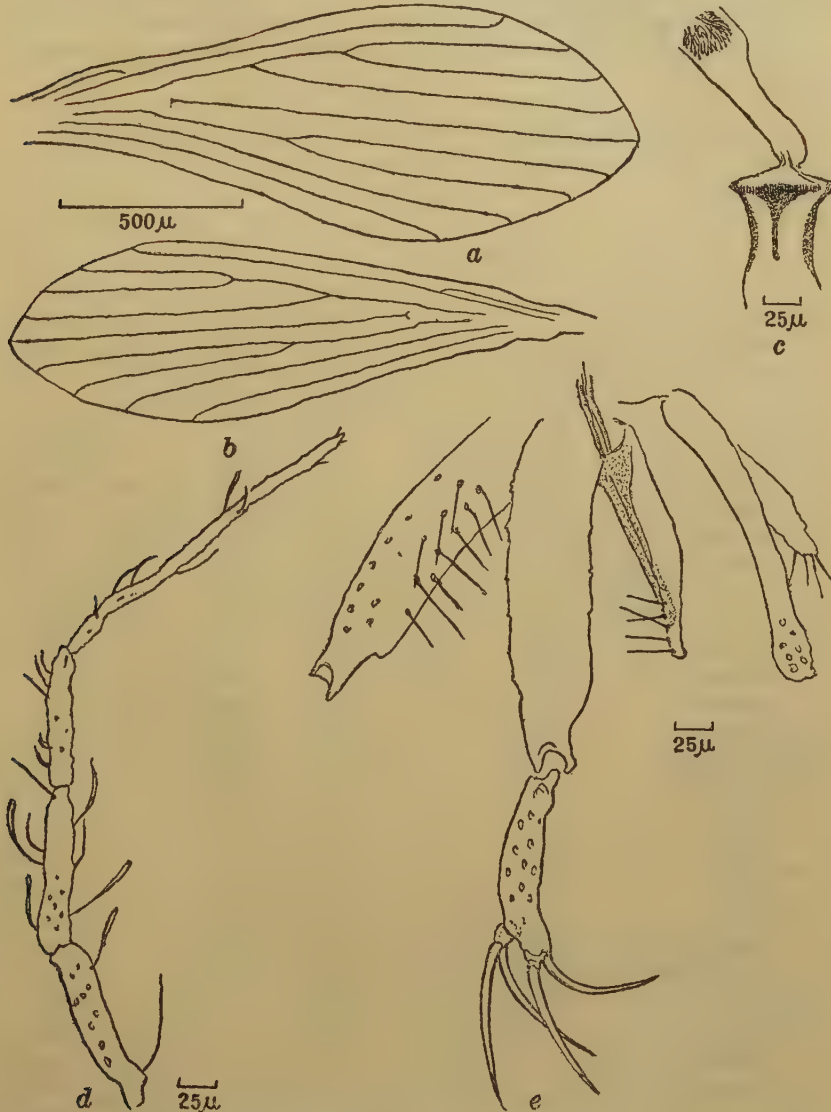


FIG. 3. *Phlebotomus torrechantei* sp. nov.; a, wing, female; b, wing, male; c, buccopharynx; d, palps; e, genitalia.

third; fifth segment slightly longer than the combined lengths of third and fourth segments (fig. 3, d).

Antennæ.—Segment III is about 2.5 times segment IV and shorter than the combined lengths of segments XII to XVI. Geniculate spines present.

Buccopharynx.—The dark pigmented area in the buccal cavity is funnel-shaped, with a long stem. The teeth are numerous, slender, and side by side like a fine comb. The œsophageal end of the pharyngeal bulb carries a brush of stout spines (fig. 3, c).

Thorax and abdomen.—Similar to those of the two preceding species.

TABLE 3.—Measurements of *Phlebotomus torrechantei* sp. nov. in millimeters.

	Female 1.	Female 2.	Male 1.
Body:	mm.	mm.	mm.
Clypeus and head.....	0.350	0.350	-----
Thorax.....	0.500	0.500	0.475
Abdomen.....	1.400	1.400	1.300
Superior clasper, segment 1.....	0.150	0.150	0.230
Total length.....	2.400	2.400	-----
Labium.....	0.200	0.200	-----
Antenna:			
Segment III.....	0.387	0.387	0.400
Segment IV.....	0.150	0.150	0.150
Segment V.....	0.150	0.150	0.150
Segment VI.....	0.150	0.150	0.150
Segments XII to XVI.....	0.475	0.430	0.560
Segments I, II, and VII to XI.....	0.900	0.925	0.900
Total length.....	2.212	2.192	2.310
Palp:			
Segment 1.....	0.037	0.037	0.033
Segment 2.....	0.075	0.062	0.075
Segment 3.....	0.112	0.116	0.103
Segment 4.....	0.100	0.100	0.100
Segment 5.....	0.225	0.225	0.206
Total length.....	0.549	0.540	0.522
Wing:			
Length.....	1.700	1.750	1.600
Width.....	0.650	0.600	0.500
Hind leg:			
Femur.....	0.850	-----	0.700
Tibia.....	1.200	-----	1.160
Tarsus segment 1.....	0.600	-----	0.550
Tarsus segments 2 to 5.....	0.750	-----	0.675
Total length *.....	3.400	-----	3.085
Superior clasper:			
Segment 1.....	-----	-----	2.230
Segment 2.....	-----	-----	0.125
Intromittent organ.....	-----	-----	0.087

* Not including coxa and trochanter.

TABLE 4.—Differential characters of the three new species and the other local species of the *Phlebotomus minutus* group.

Area or organ.	<i>P. nicoi</i> Banks.	<i>P. mangas</i> Ma- nalang.	<i>P. hitchensi</i> Ma- nalang.	<i>P. heiseri</i> Ma- nalang.	<i>P. bigiti</i> sp. nov.	<i>P. dayapensis</i> sp. nov.	<i>P. torrechantei</i> sp. nov.
Female:							
Buccal armature—							
Pigmented area	Cylindrical.	Triangular.	None.	Triangular (pale)	Bell-shaped.	Mus h r o m- shaped.	Funnel-shaped.
Teeth.	Two or more rows, few con- ical and sep- arate.	One row, very many slender, not separate.	One row, about 10 separate, low and con- ical.	Two rows; an- terior short, posterior long.	One row, 10 to 12 long sepa- rate, pointed.	One row, 24 or more, not pointed.	One row, many slender, not separate, not pointed.
Pharyngeal bulb, posterior end.	Several rows of slender spines pointing back- wards.	Many long fila- ments spines point- ing back- wards.	No spines.	Thick brush of long stout spines.	Thick brush of long stout spines.	No spines.	Thick brush of spines.
Wing, α and β	$\alpha = \beta$	$\alpha = 2 \times \beta$	$\alpha = 2 \times \beta$	$\alpha > \text{or } < 2 \beta$	$\alpha > 2 \beta$	$\alpha = \beta$	$\alpha < 2 \beta$.
Spermathecae	Barrel-shaped.	Barrel-shaped.	Bottle-shaped.	Pear-shaped.			
Male:							
Buccal armature—							
Pigmented area	Same as female.	None.	None.	Same as female.	Same as female.	None.	Same as female.
Teeth.	do.	Fewer, larger, and more separate than in female.	Same as female.	Fewer than female.	Fewer and shorter than female.	Fewer and shorter than female.	Do.
Genitalia; macrochaetae.	Three apical, one subapical (pigmented).	All apical (pig- mented).	Two apical, two subapical (not pigmented).	Two apical, two subapical (not pigmented).	Two apical, two subapical (pig- mented).	Three apical, one subapi- cal (not pig- mented).	Two apical, two subapical (pig- mented).
Mesal surface proximal segment, superior clas- per.	With thick brush of long stout hairs.	None.	Brush of slen- der hairs.	Thin brush of long hairs.	Thin brush of long slender hairs.	Thin brush of long slender hairs.	Thin brush of long slender hairs.

Wings.—Voluminous and symmetrical venation characterized by long α and δ and relatively short β and γ so that $\alpha < \beta + \gamma$ or 2β , while δ is just a trifle shorter than $\beta + \gamma$ (fig. 3, *a*).

Hind legs.—Total length 1.4 times the body. Total length, 3.4 millimeters.

MALE

Only one male has been examined. Palp is shorter while the antenna is longer than those of the female. Wings are symmetrical as in the female but α is not so long, it being shorter than the combined lengths of β and γ ; β , γ , and δ are all about the same length (fig. 3, *b*). Buccopharyngeal armatures are similar to those of the female but with fewer teeth in the buccal cavity and fewer spines in the pharynx.

Genitalia.—Similar to those of the preceding two species. Macrochætæ pointed, pigmented basally, two apical, two sub-apical (fig. 3, *e*).

Table 4 gives the differential characters of the three new species and the other Philippine species of the *minutus* group.³

SUMMARY

1. Three new species of Philippine *Phlebotomus* of the *minutus* group are described, and the important differential characters are given.

³ Manalang, C., Philip. Journ. Sci. 41 (1929) 175; 42 (1930) 283-305.

ILLUSTRATIONS

TEXT FIGURES

- FIG. 1. *Phlebotomus bigtii* sp. nov.; *a*, wing, female; *b*, buccopharynx; *c*, wing, male; *d*, pharyngeal bulb; *e*, palps; *f*, genitalia.
2. *Phlebotomus dayapensis* sp. nov.; *a*, wing, female; *b*, buccopharynx; *c*, wing, male; *d*, pharyngeal bulb; *e*, palps; *f*, genitalia.
3. *Phlebotomus torrechantei* sp. nov., *a*, wing, female; *b*, wing, male; *c*, buccopharynx; *d*, palps; *e*, genitalia.

MALARIA TRANSMISSION IN THE PHILIPPINES, II
INFECTION OF ANOPHELES FUNESTUS GILES² (MINIMUS) WITH
NOTES ON ITS DENSITY, PROBABLE RANGE OF FLIGHT,
AND LARVAL CONTROL¹

By C. MANALANG

Of the Philippine Health Service, Manila

ONE TEXT FIGURE

A preliminary survey for natural malaria infection in about 2,700 anophelines caught in La Mesa and South Portal camps, Novaliches water project, Rizal Province, Luzon, in 1927 has already been reported.³ Twenty-seven of 2,283 *Anopheles funestus* (*minimus*) were found infected. The figures submitted were not satisfactory, and the different species dissected were not numerically well represented. In the preceding paper, more-conclusive figures based on a two-year observation on about 65,000 mosquitoes with twelve species were given. They were caught in eight camps of the water project and the barrios of San Francisco del Monte and Novaliches. For the localities observed, which are topographically and entomologically typical of nearly every known malarious district in the Philippines, the observation was conclusive that *A. funestus* is the most important natural malaria vector. Laurel's⁴ preliminary work on blood meals of *funestus* shows that 79.43 per cent of them were of human origin. The other species bit either cows or horses. If malaria control in the Philippines is ever to succeed through mosquito reduction, a thorough knowledge of the factors influencing the vector, favorably or otherwise, is indispensable.

The present paper is based on data collected from January, 1928, to May, 1930, on *A. funestus* caught in South Portal camp (see fig. 1), a temporarily inhabited area of the water project, and where over 200 positives were found. The place being

¹ From the field laboratory, division of malaria control, Philippine Health Service, Tungkong Manga, Bulacan.

² Manalang, Philip. Journ. Sci. 43 (1930) 247.

³ Manalang, Philip. Journ. Sci. 37 (1928) 123.

⁴ Monthly Bull. Philip. Health Serv. 10 (1930) 153-166.

malarious, Paris-green control of *funestus* breeding (streams) and quinine prophylaxis were instituted following the opening of the camp in 1927. Infected *funestus* had already been caught in this camp and with the prospect that the work would continue for some time, it became a suitable place for study. The camp is about 20 kilometers northeast of Manila, some 100 meters above sea level, hilly, mostly covered with cogon grass, with scattered trees, and cut by permanent and temporary (rainy season) streams. The banks of the streams are lined with trees and bushes or bamboo.

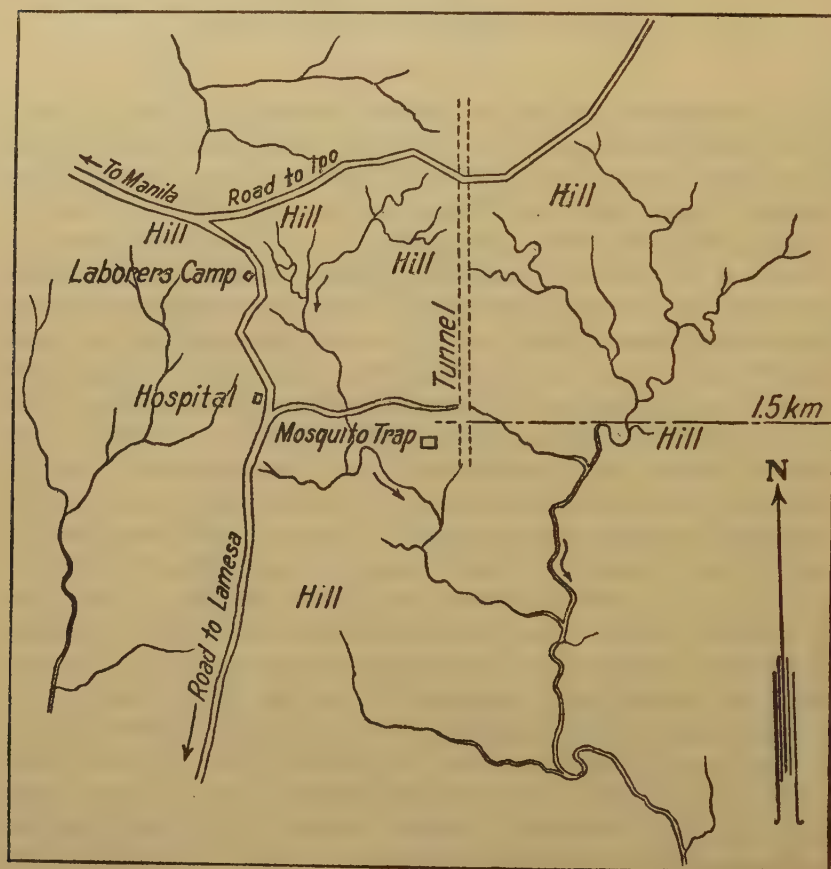


FIG. 1. Sketch map of South Portal.

INHABITANTS, MALARIA CASES, AND BLOOD FINDINGS

The laborers, who formed the bulk of the population and from whom the mosquitoes obtained malaria constantly, changed from camp to camp and fluctuated in number between 70 and 322. Many of them had already had malaria the year before. Table

TABLE 1.—Population and malaria cases at South Portal.

Month.	1928				1929				1930			
	Popula- tion.	Relap- sing cases.	Nonre- lapsing cases.	Total.	Popula- tion.	Relap- sing cases.	Nonre- lapsing cases.	Total.	Popula- tion.	Relap- sing cases.	Nonre- lapsing cases.	Total.
				P. ct.				P. ct.				P. ct.
January	70	4	1	5	7.00	210	10	0	10	4.76	6	10
February	77	0	0	0	0.00	115	8	4	7	6.00	4	10
March	110	0	0	0	0.00	245	8	12	15	6.10	0	6
April	106	3	0	3	2.80	284	7	1	8	3.00	0	1
May	102	9	0	9	8.80	226	14	0	14	6.10	0	1
June	116	0	10	10	8.60	287	14	10	24	8.36		
July	110	4	0	4	3.60	268	9	5	14	5.00		
August	90	16	0	16	17.00	322	9	3	12	3.70		
September	141	16	0	16	11.34	272	8	7	15	5.50		
October	141	10	2	12	8.50	267	7	4	11	4.10		
November	159	3	3	6	3.80	(*)	(*)	(*)	(*)	6.50		
December	180	6	5	11	8.40	170	8	3	11	6.50		
Total		71	21	92			92	49	141		17	27

* Data lost.

1 shows the monthly population and malaria cases.⁵ The figures represent admissions, not individuals, and show that about two-thirds of the cases had suffered repeated attacks during the month. Their quarters were of bamboo, roofed with cogon or tin, and unscreened. Very few used mosquito nets. Quinine-prophylaxis compliance on the part of the laborers was at times doubtful, as shown by the very low percentage of positive Mayer's test in the urine of those who claimed to have taken the drug, and by not infrequently finding tablets of quinine on the road. Infirmary cases usually resumed work as soon as their symptoms disappeared although many still carried the parasites, particularly gametes. The influence of the neighboring camps, La Mesa to the south and North Portal to the north (both with

TABLE 2.—Blood smears from surveys and cases.

SURVEYS.			
Date.	Examined.	Positive.	
			Per cent.
September, 1928.....	40	3	7.5
September, 1929.....	91	18	19.78
March, 1930.....	130	1	0.70
INFIRMARY CASES.			
1928.....	* 178	86	35.4
1929.....	* 265	94	48.3

* Number of examinations; not individual cases

malaria and under larval control and quinine prophylaxis), on the malaria in man and mosquito in South Portal cannot be estimated but must have been considerable. Large animals were not allowed in the area. It is evident that the incidence of malaria in man and *A. funestus* in this camp may not have been as natural as that obtaining in localities with a permanent population that leads a normal life, and where no control measures are instituted. Even if blood smears were taken at frequent regular intervals, the parasite rates would not be a satisfactory criterion to evaluate the results of antilarval control measures due to the changing population and quininization. Blood examinations are given in Table 2. Thick and thin smears

⁵ From the reports of the physician in charge, Dr. Modesto Castillo, under supervision of Dr. A. Ejercito. Dr. Raymond Miller took charge from January, 1930.

were used. *Plasmodium vivax* was slightly more predominant than *P. falciparum*. No *P. malaria* was found. For reasons already known to most students of malariology, case records and blood findings need not necessarily show correlation with mosquito infection.

MOSQUITO CATCHES AND DENSITY

Table 3 gives the monthly catches during the period of observation, which averaged twenty-three days a month. The influence of larval control on the adult density is not known. During January and February, 1928, 924 *A. funestus* were caught by exposure as they were only rarely found in the houses. From March till December, 4,341 were caught in the human-baited trap, or a total of 5,265 *funestus* for 1928; 1,260 for 1929; and only 56 from January to May, 1930. No males were caught in this trap at any time.⁶ The trap was located in a valley not far from a stream, and in the center of the Paris-green control area with a radius of 1.5 kilometers. It was a small wire-screen house, 2.5 by 2.5 by 2.5 meters, with screen ceiling and four doors. Mosquitoes that entered between 7 and 10 p. m. were spotted on the screen with a flashlight and covered with a test tube. The catcher slept under a mosquito net, with or without a light in the trap, and with the doors open till 4 a. m. when they were closed. The trapped mosquitoes were caught in the morning and sent to Manila with those caught during the night, daily except holidays. The dead and weak were identified and dissected at once, while the live ones were transferred into wide-mouthed ounce bottles with a pledget of cotton saturated with water or dilute glucose water and stored in a refrigerator at 23 to 25° C. At this temperature, they were inactive and lived long enough to allow some positive blood meals to develop into oöcysts. From September, 1929, the mosquitoes were dissected in the field laboratory at Tungkong Manga. A mosquito net about the size of the trap with a long slit opening on one side was used successfully in North Portal and Tungkong Manga. For adult mosquito surveys of different places, this portable trap is the most convenient. Trapping of *A. funestus*, which is an "out-of-doors" species, has the following advantages over expo-

⁶The catches from March, 1928, indicate the monthly density since they were collected in the same trap by one man exposed during a definite period of time. There is no information on the difference in trap catches with one or two men in the trap. Difference in individual attractiveness has not been studied. Laurel's work, however, shows that *A. funestus* has marked avidity for man.

TABLE 3.—*Monthly Anopheles funestus catch and infections in South Portal.*

Month.	1928					1929					1930				
	Mosqui- toes caught.	Positive.			Mosqui- toes caught.	Positive.			Mosqui- toes caught.	Positive.					
		Sto- mach.	Salivary gland.	Total infected.		Sto- mach.	Salivary gland.	Total infected.		Sto- mach.	Salivary gland.	Total infected.			
January.....	723	9	4	13	1.8	93	0	1	1	37	0	0	0	P. ct.	
February.....	201	3	3	6	3.0	65	2	0	2	5	0	0	0	0	
March.....	567	7	6	13	2.3	90	3	4	7	6	0	0	0	0	
April.....	498	3	8	11	2.2	170	1	1	2	7	0	0	0	0	
May.....	562	16	17	33	5.8	124	2	2	4	1	0	0	0	0	
June.....	469	6	11	17	3.6	313	2	0	2	2	0	0	0	0	
July.....	735	23	10	33	4.5	148	0	0	0	0.6					
August.....	490	16	7	23	5.0	81	1	0	1	0.0					
September.....	371	8	7	15	4.0	43	0	0	0	0.0					
October.....	671	9	2	11	1.7	29	0	0	0	0.0					
November.....	255	3	2	5	1.9	47	0	0	0	0.0					
December.....	223	4	6	10	3.6	57	1	0	1	1.8					
Total.....	5,765	107	83	190	-----	1,260	12	8	20	56	0	0	0	0	

sure: The catcher does not contract the disease; personal equation is reduced to a minimum; catching is easier, with less chance of escape; being a circumscribed fixed unit, the collection is a reliable index of mosquito density and reveals the efficiency of larval control; the sporozoite rates in those caught will explain the prevalence of malaria among the susceptibles and the causes of certain behaviors of malaria incidence, which are at present obscure.

FLIGHT RANGE AND LARVAL COLLECTIONS

The difficulty of rearing *A. funestus* from larva or catching and maintaining alive for a few days several thousands of them precluded direct flight observation on stained mosquitoes. It would be expensive and impractical to measure *funestus* density in the centers of several nearly identical well-supervised Paris-green control areas, each with a different radius, the catches simultaneous and under the same meteorological conditions. It is far simpler to observe the flight range of mosquitoes breeding in a solitary marsh or fishpond by catching them at different distances at the same time.

The object of larval control is to reduce the density of the transmitter as much below the minimum effective number in the locality as possible. This number is variable, as will be shown in the following article, and is inversely proportional to the number and accessibility to the mosquito of suitable malaria-gamete carriers. The most that could be observed in South Portal was to determine if the economic radius of Paris-green control (1.5 kilometers) was effective in reducing *funestus* density so that those systematically caught during a reasonable period would no longer show infection.

Table 2, of monthly trap catches during the period of observation, shows a distinct decrease in their density from November, 1928, or, after ten months of trapping, a period apparently too distant to have any relation to the larval control that was begun in 1927. The reduced catch continued through 1929 and five months of 1930. Unfortunately, there was no record of monthly adult catches previous to the larval control. What would have been the catches during the entire period of observation had Paris green not been used is not known. The longest time *A. funestus* has been kept alive under artificial conditions was about one month. Whether they live longer in nature or not is unknown. For the two months after larval control was suspended (April and May, 1930) only eight *funestus* were caught

in the trap. The catches show an apparent natural decrease in density since November, 1928. Similar decrease has been observed in two other places under larval control.

A record was kept of the weekly number of larvæ caught at five definite stations on the streams in the area to check the efficiency of spraying. Throughout the period of observation (dippings in portions of the streams other than the stations) larval breeding in the control area was practically nil at times, and invariably much less than the breeding beyond the control limits. Estimation of larval density by their number per dip was unsatisfactory, due to the marked variation in breeding and the depth of the water in which they breed, a condition also observed in uncontrolled streams. The findings of pupæ and full-grown larvæ were an indication that the spraying was not done or at least not thorough. Table 4 shows the monthly number of larvæ thus collected.⁷ It will be noted that the larvæ collected were few during the period of high adult catches, and relatively many in the latter half of 1929 and in 1930 when the adult catches were low. It is, therefore, probable that most of the *funestus* caught in the trap had migrated from their distant breeding places into the control area. The dis correlation between anopheles larval breeding and adult density, regardless of the proximity of man, has already been observed in the other localities and cannot be explained. Gater⁸ had a similar experience with *A. aconitus* Donitz (a species closely related to *funestus*) in Malaya. Barber⁹ states that *aconitus* is capable of long flight. Hackett,¹⁰ who visited the Philippines in 1928 said, "In seven days spent in the Islands, I did not catch a single one (*minimus*) although a sporting colleague offered as high as a peso apiece for adult specimens. At the same time the larvæ were abundant." Swellengrebel,¹¹ writing on anophelism for the Malaria Commission of the League of Nations in their tour through eastern Europe and Italy, May to September, 1924, relates their experiences with *A. maculipennis* as follows:

Often we could not find any larvæ in collections of water apparently suitable for breeding, not only where these had been petrolised or dealt

⁷ Compiled from the reports of the physician in charge.

⁸ Ann. Report, Inst. for Med. Res. Kuala Lumpur, F. M. S. (1927) 29.

⁹ Philip. Journ. Sci. 13 (1918) 1.

¹⁰ So. Med. Journ. 22 (1929) 367-371.

¹¹ League of Nations Health Organization. Malaria Commission. Report on its Tour of Investigation in Certain European Countries in 1924. Geneva (1925) 174.

TABLE 4.—Monthly catches in the larval stations at South Portal.^a

Month.	1928					1929					1930				
	Small.	Medium.	Large.	Pupa.	Total.	Small.	Medium.	Large.	Pupa.	Total.	Small.	Medium.	Large.	Pupa.	Total.
January-----	280	118	62	0	460	19	28	6	0	53	200	124	68	0	392
February-----	756	513	238	0	1,507	42	20	0	0	62	229	165	67	3	464
March-----	351	85	29	0	465	33	20	13	0	66	179	145	15	10	349
April-----	139	0	0	0	139	77	33	23	0	133	176	112	98	0	386
May-----	125	25	0	0	150	32	23	3	0	58	---	---	---	---	(b)
June-----	100	40	22	0	162	79	23	12	0	119	---	---	---	---	(b)
July-----	47	12	3	0	62	25	15	6	0	46	---	---	---	---	(b)
August-----	120	45	23	0	188	24	14	23	0	61	---	---	---	---	(b)
September-----	38	12	0	0	50	354	118	35	0	507	---	---	---	---	(b)
October-----	42	19	0	0	61	465	128	71	0	664	---	---	---	---	(b)
November-----	22	12	2	0	36	(c)	(c)	(c)	(c)	---	---	---	---	---	(b)
December-----	22	8	0	0	30	135	112	27	0	274	---	---	---	---	(b)

^a Compiled from the monthly reports of Doctors Castillo and Miller. Incidence of *A. funestus* larvae as identified in the malaria laboratory: 1928, 94.2 per cent; 1929, 62.6 per cent; 1930, 46.5 per cent. The other species were *A. barbrostris* v. d. Wulp and *A. sinensis* Wied.

^b No collection.

^c Record lost.

with in another way but also where no anti-larval measures had been taken (*e. g.*, in Ilfov district and round Galatz in Roumania or on the outskirts of the town Schachtnaja, Russia), although anophelines were very numerous in stables, and in some cases the presence of males proved the presence of newly hatched broods. This shows that our means of ascertaining the presence of breeding-places were inadequate or that more distant breeding places, lying outside the range of immediate observations, influenced the local anophelism.

It may be that *funestus* migrates a long distance from the breeding place during the first few days of life when a blood meal is as yet not needed. It is also possible that even trapping fails to get them. There are no data on the influence of wind. From our present knowledge, it is probable that the flight range of *funestus* is more than 1.5 kilometers and renders the economic radius of Paris-green control ineffective, unless the breeding is strictly limited within the area under control, a rare condition to find in malarious regions. It is also obvious that an adult mosquito collection, preferably using a portable trap, is necessary and gives more information in regard to the density of the vector in a locality than the larval collection alone.

MOSQUITO INFECTION

Table 3 shows the number of *A. funestus* caught, dissected, and found infected in 1928 and 1929, which varied from 0.6 to 7.7 per cent (stomach and salivary glands combined) a month. Constant mosquito infection was demonstrable from January, 1928, till June, 1929, and then none was found till May, 1930 (excepting one infected mosquito each in August and December, 1929) when the monthly catch averaged only thirty-six for the nine negative months. The average monthly catch during the twenty positive months was 338. In Strickland's¹² observations on natural infections on 1,353 *funestus* caught by trapping in coolie lines in Cachar (Assam), April to November, 1927, positives were found from June to November with a monthly average of 215 and none was found in April and May among eight and fifty-two *funestus*, respectively. His monthly infection rates were from 2.6 to 5.5 per cent. The influence of quininization, the movement of the laborers and suitable carriers from one camp to another is not known. The diminution in catches is evidently one of the causes of the negative findings since old malaria cases were still present during the negative months (monthly rates

¹² Indian Journ. Med. Res. 17 (1929) 174-182.

of 1 to 6.2 per cent). Had more mosquitoes been captured, and the carriers been suitable and accessible, infection would have been found throughout the entire period of observation. The findings indicate that given a constant proportion of suitable parasite reservoirs and susceptibles, endemic, seasonal or epidemic malaria, or its disappearance in a community in the Philippines depends considerably on adult *funestus* density and not on temperature (monthly mean 23.9 to 27.8° C.). An analysis of data from the ten places studied, defining the meaning of the direct relationship of *funestus* density to the amount of malaria transmission, will be the subject of the following paper. The influence of meteorological factors on malaria transmission will also be dealt with separately. Whether or not there are places where *funestus* abounds with suitable carriers but with little or no malaria will have to be shown by careful blood and adult mosquito survey.

CONTROL MEASURES

The accompanying map (fig. 1) shows the South Portal control area. It was recommended by the Rockefeller Foundation representative¹³ that Paris green be sprayed on "all anopheles mosquito breeding places" and its use in several demonstration units was started in the latter part of 1926. In 1927¹⁴ larval control was limited to streams, the breeding places of *funestus*.

Weekly spraying of the streams with 1 per cent Paris green in road dust was carried on by three laborers and an inspector under the supervision of a field director and a physician. Paris-green mixture was biologically tested in the laboratory with proper control and was known to be able to kill at least 90 per cent of *funestus* larvæ in one hour.¹⁵ The streams were divided into sections so that each was sprayed once a week. A record was kept of the weekly number of larvæ collected from definite stations, to check the efficiency of spraying. With this arrangement, it was believed that there was efficient larval control. During floods spraying was stopped, as the larvæ were carried away. Every evening a sanitary inspector gave 10 grains of quinine sulphate to each person in the camp. The efficiency of this quinine prophylaxis has already been commented on.

¹³ Ann. Rep. Philip. Health Serv. (1926) 247-248.

¹⁴ Ann. Rep. Philip. Health Serv. (1927) 165.

¹⁵ Manalang, C., Monthly Bull. Philip. Health Serv. 7 (1927) 725.

COMMENTS

The finding of infected mosquitoes regularly from January, 1928, to June, 1929, shows that not only the mosquito control was ineffective, but the quinine prophylaxis as well, in so far as reducing the source of infection of both man and mosquitoes was concerned. Although quinine prophylaxis was not well received by the laborers, whatever amount they were forced to take probably contributed much in keeping them working although many were found to have parasites in their blood.¹⁶ The situation was made less serious because the population in South Portal was already immune and susceptibles were not imported.

Even if the larval control as carried out were successful and economical (the cost in the camp was 11.50 pesos per capita per annum, exclusive of quinine), the method requires a special trained personnel to do nothing but that work. It cannot be placed in the hands of the regular health personnel. Larval control with Paris green may be justified in projects that can afford to spend freely and for experimental purposes, provided the radius is more than 1.5 kilometers.¹⁷ The safe radius is unknown and may vary according to the peculiarities of the locality. Construction of portable mosquito-proof laborers' quarters by the contractor might have given better results. Quinization or, better still, the use of plasmochin compound, as tested by Ejercito,¹⁸ and treatment of cases should still be employed as the method of choice.

Anopheles funestus caught in the trap is a good index of the mosquito density and effectiveness of larval control, while a malaria survey of those caught is useful to evaluate antimalaria measures when the population is inconstant and periodical blood surveys are unreliable. It is also apparent that trapping of *funestus* as a control measure is not only impractical but ineffective.

The natural decrease in the density of adult *funestus* from November, 1928, till 1930 is very important in mosquito-control

¹⁶ See reference, footnote 3.

¹⁷ In April, 1931, Doctor Ejercito and Mr. Laurel contracted *falciparum* infections from *funestus* bites whose malarial infections were derived from human carriers living 2.5 kilometers away from their camp. In the May meeting of the Advisory Board for Malaria Control, it was agreed to extend the radius of larval control from 1.5 kilometers to 3 kilometers.

¹⁸ Journ. Philip. Is. Med. Assn. 9 (1929) 229.

projects as it could easily have been attributed to larval extermination. Disturbance of *funestus* density due to larval control is not known. Disturbance of *funestus* infection rates due to changes of population and quinine is also not known.

SUMMARY

1. Data on *Anopheles funestus* caught in a human baited trap in South Portal camp of Novaliches water project show malarial infection to have been present in them throughout 1928 and eight months of 1929. The infection rates varied from 0.6 to 7.7 per cent per month. The disturbance in infection rates due to movement of the population and to quininization is not known.

2. Infections were not found when the catches were reduced to an average of 36 *funestus* per month during the nine negative months, while the average monthly catch during the twenty positive months was 338, and shows that malaria transmission is mainly dependent on *funestus* density. Disturbance in adult *funestus* density due to antilarval measures is not known.

3. Natural diminution in adult *funestus* density has been noted and could not be attributed to larval extermination.

4. Adult *funestus* catches in the trap is an effective index of mosquito density and reveals the efficiency of larval control, while malaria survey of those caught may be used to evaluate antimalaria measures when the population is inconstant and periodical blood surveys prove unreliable.

5. The flight range of *funestus* is probably more than 1.5 kilometers, the economic radius of Paris-green control, and renders this method ineffective as a control measure. Trapping as a control measure is impractical and not effective.

6. The number of larvæ breeding in a locality does not necessarily indicate the adult density in the immediate vicinity of human habitation. An adult mosquito survey, preferably by trapping, should be a part of the anopheles mosquito survey.

ILLUSTRATION

TEXT FIG. 1. Sketch map of South Portal.

PHILIPPINE ROSIN
FROM PINUS INSULARIS (ENDLICHER)

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and

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ONE PLATE

Benguet pine (*Pinus insularis* Endlicher) forms extensive forests in the mountain regions of northern Luzon. Some months ago we examined samples of resin tapped from the Benguet pine, and our results showed that turpentine of excellent quality and high pinene content¹ is obtained from it.

Recently we investigated the rosin content of Benguet pine resin and found the rosin to be of very high grade. The results are recorded in this paper.

Rosin (colophony) consists principally of organic acids, commonly called abietic acid, and a small percentage of neutral material termed resene. Rosin is used considerably in the manufacture of soap, and in the varnish industry for the preparation of varnishes and resinate driers. It is also used in the manufacture of rosin oil and in the paper industry for sizing paper. Rosin is also employed in the manufacture of other substances such as sealing wax, oil cloth, printing ink, matches, and for various other purposes.² Glycerinated rosin (ester gum) is used considerably in the manufacture of pyroxylin enamels and lacquers³ which is an industry that seems to be expanding rapidly.

During the year 1928 a total of more than nine hundred thousand barrels of rosin were consumed⁴ by industrial concerns in the United States while over one million barrels were exported.⁵

¹ Philip. Journ. Sci. 45 (1931) 233.

² Wyman, L., Florida Dept. Agr. Bull. 25 N. S. (1929) 42.

³ Wilson, S. P., Pyroxylin enamels and lacquers.

⁴ Chem. Met. Eng. 37 (1930) 196.

⁵ Yearbook U. S. Dept. Agr. (1930) 944.

Information concerning the cultivation of pine trees and the production and uses of turpentine and rosin is given by various Government publications such as farmers' bulletins on longleaf pine, slash pine, and pine nursery stock.⁶

Recently, there have appeared two articles⁷ which give a very good resumé of the present status and future prospects of the turpentine and rosin industry.

Methods for the preparation of high-grade abietic acid and derivatives, such as esters and nitro compounds, from pine-tree rosin are given in recent articles.⁸

Some years ago Brooks⁹ tested the rosin obtained from the resin of Benguet pine trees. The trees selected for procuring the resin were growing near Baguio, a summer resort situated at an elevation of about 1,500 meters in the mountain province of the Philippines. According to Brooks the Baguio pine rosin contains over 90 per cent abietic acid.

EXPERIMENTAL PROCEDURE

Since the tests, made some years ago by Brooks, gave very promising results it seemed desirable to continue this work.

During the spring of 1930, Foresters J. Fontanoza and P. D. Esguerra, of the Philippine Bureau of Forestry, tapped a number of Benguet pine trees in and near Baguio. The resin obtained from these trees was then shipped to the Bureau of Science laboratories in Manila where an investigation was made of it.

Table 1 gives the location and approximate diameter of the pine trees selected for this investigation. The dates of tapping the trees, number of chippings, and the yield of resin are also included. As shown by the data, trees of various sizes were selected for our experiments.

⁶ Mattoon, W. R., U. S. Dept. Agr. Farmers' Bull. 1256 (1922); 1486 (1926).

Wakeley, P. C., U. S. Dept. Agr. Leaflet 32 (1929); 35 (1929).

Wyman, L., Florida Dept. Agr. Bull. 25 N. S. (1929).

Hayes, R. W., and P. C. Wakeley, Louisiana State Univ. Bull. 21 N. S., No. 3, pt. 2 (1929).

Veitch, F. P., and V. E. Grotlisch, U. S. Dept. Agr. Bull. 898 (1920).

⁷ Speh, C. F., Journ. Chem. Ed. 7 (1930) 2322.

Bent, L. N., Journ. Chem. Ed. 7 (1930) 2365.

⁸ Kesler, C. C., A. Lowy, and W. F. Faragher, Journ. Am. Chem. Soc. 49 (1927) 2898.

Goldblatt, L. A., A. Lowy, and W. B. Burnett, Journ. Am. Chem. Soc. 52 (1930) 2132.

⁹ Philip. Journ. Sci. § A 5 (1910) 229.

TABLE 1.—Location and diameter of Philippine trees selected for collecting Benguet pine resin.

Tree No.	Location.	Diameter. ^a	Date of tapping.	Duration of chipping.	Number of chippings.	Yield of resin.
		cm.	1930	1930		g.
1	Forbes Park.....	40.5	Jan. 22...	Jan. 29 to July 30..	27	574.0
2	do.....	37.0	do.....	do.....	27	505.6
3	do.....	37.5	do.....	do.....	27	1,898.0
4	do.....	33.5	do.....	do.....	27	882.8
5	do.....	48.5	do.....	do.....	27	1,220.6
6	do.....	57.5	do.....	do.....	27	1,346.5
7	Irisan near Naguilian Road.	42.5	Feb. 10...	Feb. 17 to July 31..	27	1,137.9
8	do.....	41.0	do.....	do.....	27	883.2
9	do.....	35.5	do.....	do.....	27	1,779.5
10	do.....	34.0	do.....	do.....	27	975.4
11	do.....	46.0	do.....	do.....	27	2,463.6
12	do.....	57.0	do.....	Feb. 17 to July 30..	35	2,448.3
13	do.....	38.0	do.....	do.....	35	1,753.1
14	do.....	47.0	do.....	do.....	35	1,398.6
15	do.....	42.0	do.....	do.....	35	1,471.4
16	do.....	51.0	do.....	do.....	35	3,037.3
17	Pimmaric, Trinidad.....	42.0	April 25..	May 2 to July 29..	34	1,123.6
18	do.....	62.0	do.....	do.....	34	3,683.1
19	do.....	64.5	do.....	do.....	34	1,001.6
20	do.....	61.0	do.....	do.....	34	1,136.8
21	do.....	66.0	do.....	do.....	34	917.4

^a The diameters of the trees were measured at a height of 1.3 meters from the ground.

The cup-and-gutter method was employed by the foresters in tapping and chipping the pine trees. The procedure was essentially the same as that described some years ago by Herty¹⁰ except that somewhat different tools were used. For instance, instead of using a broad ax a heavy bolo served the same purpose. After the first cut (streak) is made in the trees, most of the resin flows out during the first day, usually, and very little is obtained during the next few days. When the first cut is extended by a second chipping the resin begins to flow freely again for another day. By making new chippings frequently and continually lengthening the original cut the tree continues to yield resin for some months. A day or so after a new chipping, when the exudation has practically stopped, the resin is then poured (dipped) from the tree cup into a permanent container.

As shown by the data (Table 1) the yield of resin from individual trees varies considerably.

¹⁰ U. S. Dept. Agr. Forest Service Bull. 40 (1903) 17.

Altogether, twenty-one trees were tapped. The total resin obtained from the first tapping of these trees was combined into a composite sample (composite 1). Subsequently a number of these trees were tapped a second time. When these various samples of pine resin were received in our laboratory in Manila, they were first steam distilled to separate the turpentine from the rosin. After distillation the turpentine was separated from the admixed water and dried with calcium chloride. After draining off the water the rosin was dried in desiccators. The percentage yields of turpentine and rosin obtained from the pine resin are given in Table 2.

TABLE 2.—*Turpentine and rosin obtained from Benguet pine trees.*

Sample. *	Turpen- tine.	Rosin.
	<i>Per cent.</i>	<i>Per cent.</i>
Tree 3.....	15.33	84.67
Tree 5.....	17.02	82.98
Tree 9.....	16.18	83.82
Tree 18.....	17.47	82.53
Composite 1.....	14.58	85.42
Composite 2.....	16.57	83.43
Composite 3.....	17.23	82.77
Average.....	16.34	83.66

* Samples for trees 3, 5, 9, and 18 were obtained from a second tapping. Composite 1. Combined resin from the first tapping of trees 1 to 21. Composite 2. Combined resin from the second tapping of trees 18, 20, and 21. Composite 3. Combined resin from a second tapping of trees 10, 12, and 16.

According to Wyman¹¹ the yield of resin from pine trees varies considerably depending upon such factors as soil, weather, size of trees, species, etc. In general, the quantity of resin obtained from a tree varies directly with the size of the tree and the highest yields are obtained in the hot dry season which permits of long continuous working.

In Florida pine-tree resin, when distilled, yields an estimated average of one barrel of turpentine for three and a third barrels of rosin. Expressed in percentage that would be 23.09 per cent of turpentine to 76.91 per cent of rosin by volume. According to our results (Table 2), Benguet pine-tree resin gave 16.34 per cent of turpentine to 83.66 per cent of rosin by weight, which would be equivalent to 20.93 per cent of turpentine to 79.07 per cent of rosin by volume. This is about a barrel of turpentine to three and four-fifths barrels of rosin. It would seem that

¹¹ Florida Dept. Agr. Bull. 25 N. S. (1929) 33.

TABLE 3.—*Analysis of Benguet rosin.*

Sample. ^a	Tree—				Composite—			American colophony pale. ^b
	3	5	9	18	1	2	3	
Specific gravity.....	1.054	1.062	1.058	1.033	1.068	1.054	1.072	1.069
Melting point:								
Softens °C.....	105	107	104	58	98	55	95	
Melts °C.....	119	115	110	66	107	62	112	
Acid value:								
Titration with aqueous alkali (A).....	164.5	162.7	161.2	148.9	165.3	149.4	164.8	157.9
Titration with alcoholic alkali (a).....	164.2	161.9	160.8	148.7	161.2	149.4	164.6	154.0
Total saponification value (B).....	189.9	165.1	162.2	153.0	175.9	166.1	175.5	169.4
Ester value (B-A).....	25.4	2.4	1.0	4.1	10.6	16.7	10.7	11.5
Ester value (B-a).....	25.7	3.2	1.6	4.3	14.7	16.7	10.9	15.4
Unsaponifiable matter.....	4.54	4.84	4.6	6.82	6.68	6.71	4.35	9.25
Specific rotation A _D ^{30° C.}	-62.67	-46.02	-63.55	-41.17	-26.95	-42.73	-64.57	

^a Samples for trees 3, 5, 9, and 18 were obtained from a second tapping. Composite 1. Combined resin from the first tapping of trees 1 to 21. Composite 2. Combined resin from a second tapping of trees 18, 20, and 21. Composite 3. Combined resin from a second tapping of trees 10, 12, and 16.

^b Sample of pale American colophony analyzed by A. H. Allen and S. O. Richmond, Allen's Commercial Organic Analysis 4 (1925) 243.

in the Philippines the yield of turpentine from Benguet pine trees is somewhat less than in Florida while the yield of rosin is slightly greater.

Rosin obtained from the resin of Benguet pine is pale yellow and, when freshly prepared, has a slightly aromatic odor. In Table 3 are given the constants of Benguet rosin. There is also included for comparison some constants of American rosin. The data indicate that samples of Benguet rosin obtained from different trees seem to vary considerably in composition. It also appears that the amount of unsaponifiable matter in Benguet rosin is considerably less than in American rosin. According to Lewkowitsch¹² the unsaponifiable matter in rosin varies considerably. In American rosin it ranges from about 5 to 9 per cent and samples of French rosin gave values above 15 per cent. These figures are considerably higher than the values we obtained for Benguet rosin and in this respect it would seem that Benguet rosin is of better quality than American rosin.

Like American rosin, the melting point of different samples of Benguet rosin varies considerably, depending on the amount of rosin oil contained in the rosin.

Samples of abietic acid were prepared from Benguet rosin obtained from the resin of tree 9 (second tapping). In general, we followed the method used by Kessler, Lowy, and Faragher.¹³ Our procedure was as follows: Benguet rosin (150 grams) was dissolved in 95 per cent alcohol (562.5 cubic centimeters) and filtered. One and a half grams of extraneous material, such as small twigs, was thus removed from the rosin and a solution of the purified product was obtained. To this solution was then added 11 cubic centimeters of hydrochloric acid (36 per cent). The mixture was boiled on a water bath for about fifteen minutes. Half normal sodium hydroxide (438 cubic centimeters) was then added to neutralize the hydrochloric acid and also a fourth of the acid content of the rosin. The mixture was then heated on a water bath (reflux) for about a half hour, after which it was distilled to remove the excess alcohol. On cooling, the residue solidified to a white mass consisting of white needles. The residue was then filtered to eliminate the mother liquor and the crystals washed with a small quantity of alcohol. After draining repeatedly on filter papers the crystals were finally dried in a vacuum desiccator. The melting point was 165° to

¹² Chemical Technology and Analysis of Oils, Fats, and Waxes 1 (1921) 630.

¹³ Journ. Am. Chem. Soc. 49 (1927) 2898.

168.6° C., and the yield of this complex sodium salt of abietic acid was about 96 per cent.

To prepare abietic acid, a portion of the complex sodium salt was dissolved in warm glacial acetic acid, filtered, and allowed to crystallize. The abietic acid separated out as a slightly yellowish crystalline mass. The crystals were filtered and washed with a small amount of glacial acetic acid, after which they were allowed to drain on a porous plate, and then dried in a vacuum desiccator. The melting point of the crystals was 152° to 153.8° C. and the yield of abietic acid was about 74 per cent calculated on the weight of the sodium salt.

Abietic acid was found to be soluble in ethyl alcohol, acetic acid, acetic anhydride, chloroform, benzene, ether, and carbon bisulphide.

The molecular formula commonly assigned to the material known as abietic acid is $C_{20}H_{30}O_2$. An average of our determinations of the neutralization value of abietic acid gave 187.6. The molecular weight of abietic acid obtained from our neutralization value checks quite closely with the calculated value:

	Molecular weight.
Calculated for $C_{20}H_{30}O_2$	302.2
Found	299.1

We determined the specific rotation of our abietic acid in different solvents by dissolving 2.5 grams of abietic acid in 50 cubic centimeters of solvent and polarizing in a 200-millimeter tube. The results were as follows:

Solvent.	Specific rotation $\frac{A_{30^\circ C}}{D}$ Degrees.
Ethyl alcohol (95 per cent)	—82.54
Benzene	— 3.6
Chloroform	—63.47
Ethyl acetate	—31.21
Acetone	—79.42

According to the data above the rotation of abietic acid in different common solvents is negative and varies considerably. Virtanen¹⁴ obtained somewhat similar results with pinabietic acid.

The authors wish to thank Mr. Arthur F. Fischer, director of the Philippine Bureau of Forestry and Mr. Luis J. Reyes, chief of the division of forest products, Bureau of Forestry, for their

¹⁴ Virtanen, A. I., *Liebig's Annal. Chem.* 424 (1921) 150.

Rau, M. G., and J. L. Simonsen, *Ind. For. Rec.* 11 (1924) 210.

coöperation and assistance in this work on the chemistry of forest products.

The authors also wish to thank the forester, Mr. P. D. Esguerra, of the Philippine Bureau of Forestry, for his kindness in procuring samples of Benguet pine resin for this investigation.

SUMMARY

We have investigated the rosin obtained from the resin of Benguet pine trees growing at Baguio in the mountain province of the Philippines.

The yield of pine resin from these trees varies considerably.

The yield of Benguet rosin is somewhat larger than the yield obtained from the resin of Florida pine trees.

Samples of rosin from the pine resin of numerous Benguet trees seem to differ very much in composition.

The unsaponifiable matter of Benguet rosin is somewhat less than that of American rosin.

Like American rosin, the melting point of different samples of Benguet rosin varies considerably.

Samples of abietic acid were prepared from Benguet rosin. The yield of abietic acid calculated on the weight of the complex sodium salt of abietic acid was 74 per cent.

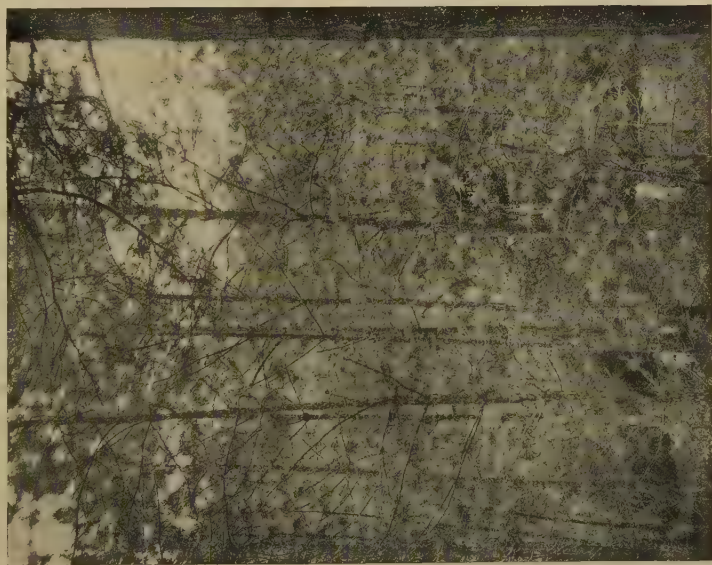
Abietic acid is soluble in a number of the common organic solvents.

There is considerable variation in the figures representing the specific rotation of abietic acid in different solvents.

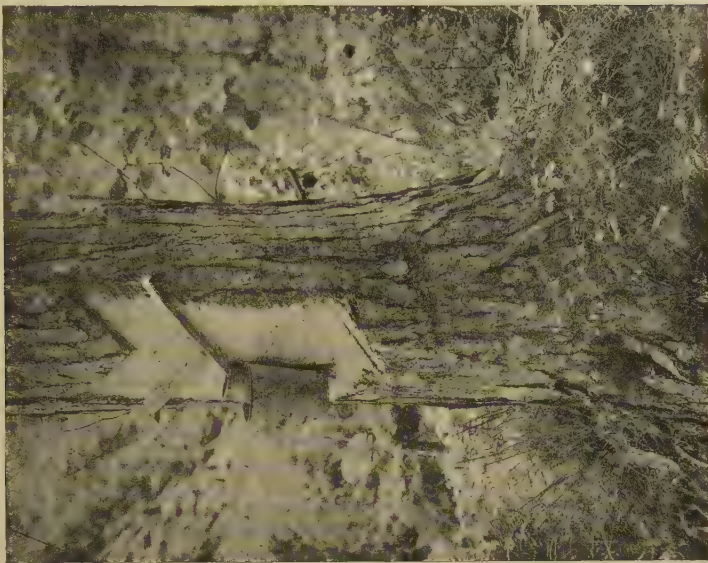
ILLUSTRATION

PLATE 1

- FIG. 1. Benguet pine forest.
2. Tapping a pine tree.



1



2

PLATE 1.

GEOLOGICAL RECONNAISSANCE OF NORTHWESTERN CAPIZ PROVINCE, PANAY, PHILIPPINE ISLANDS

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TEN PLATES

INTRODUCTION

A geological reconnaissance was made of the northwestern part of Capiz Province, Panay, in November, 1929, to study the possibilities of artesian-well drilling in that region, but as this was incidental to the study of the geological structure, the writer proceeded to make a formal geological reconnaissance with the double object of making recommendations to the Bureau of Public Works regarding the drilling of artesian wells and furnishing the Bureau of Science with a geological study of a part of the complex island of Panay.

The field work consisted in the examination of natural outcrops along the roads, trails, and shallow creeks and of the cuts along the newly built provincial roads. All data were controlled by compass and pace traverses, except in a few places where this procedure was interfered with by heavy rain. The Bureau of Forestry map was used as a base upon which our traverses were adjusted and tied to known points. The courses of a few small streams had to be revised, but outside of these minor discrepancies the base map was taken without alteration.

When the field work was carried out, from November 7 to December 10, the prevailing wind was the northeast, which brought great precipitation. This, according to the residents, usually continues until February. Due to this unfavorable weather the control of some of the data was not as accurate as the writer desired. However, this did not seriously affect the geological interpretation of the structures of the area.

LOCATION AND EXTENT OF AREA

The area covered by this reconnaissance is in the northwestern part of Capiz and extends from Campo Verde on the northwest to New Washington on the southeast and from the coast on the

¹ Resigned March 17, 1930.

northeast to the mountain front on the southwest. It is a strip of land, from 5 to 20 kilometers in width, bordering the coast for a distance of about 30 kilometers. It is approximately 200 square kilometers in extent and comprises the municipalities of Banga, Calivo, Makato, Malinao, and New Washington.

CULTURE

Calivo is the most important of these towns as it is located at the intersection of two important trade routes; namely, Aklan River and the provincial road. New Washington is next in importance; it is the port for Calivo and the distribution center of the communities bordering Banga Bay. The other towns are small, each containing two to three thousand inhabitants, with numerous smaller settlements scattered among them. The important industries are planting rice, hemp, and coconuts and, to a limited extent, cattle raising.

In none of these towns is there a water-supply system. The well-to-do collect rain water for drinking purposes, and some of them possess shallow incased wells from which water is pumped for domestic use. Some of the people living in the mountains who are favorably located get their water from springs, but the great majority depend on open surface wells. It is needless to point out here the hygienic dangers of this source of water supply. During my trip through this area, the rain was heavy and the contamination of the surface wells by surface water was at its maximum; consequently, dysentery and typhoid fever took a heavy toll from the student population of Calivo, not to mention the neighboring towns.

ACCESSIBILITY AND TRANSPORTATION

This area is accessible from Manila by several small inter-island steamships that call at New Washington every other day and occasionally in Ibahay. It usually takes two days to make this voyage, including two or three stops along the way. From the southern islands it may be reached via Iloilo, from which point one can go to Capiz, either directly by automobile or by train, and thence by steamer to New Washington. Most of the travelers prefer the latter way, which is less strenuous.

The principal routes of travel are the automobile roads, Aklan River, and Banga Bay, part of which is included in the accompanying map and located to the southeast of New Washington. The main trunk of the provincial road starts 2 kilometers north of Balete and passes through Banga, Calivo, Numancia, Makato, Tangalan, and Ibajay; from the last place it continues to Iloilo,

following the western coast of Antique Province. Two branches ramify from Calivo, a short one going northeastward to Busuang on the coast, and a longer one southeast to New Washington. From Numancia on the west side of Aklan River a branch goes southward via Lezo to Malinao. From Banga another branch goes southwest to Sigkay; from here it is projected southward to Iloilo along the valley of Aklan River. The road to Balete is part of the project to link Calivo with Capiz, the capital of the province. The barrios and settlements are connected by a network of trails, some of which are open enough for saddle animals, which, however, are not available.

Aklan River is wide and has a shifting sand bottom and a swift current, which make navigation unsafe. Only rafts and canoes moved with poles ply along this river as far as Libacao, 15 kilometers south of Rosario. Despite this handicap, however, more products are transported on this river than on the automobile roads parallel to it.

Banga Bay is navigable by canoes and shallow-draft boats. Its affluents, the Cailojan, Jal-o, and other rivers, are also navigable for short distances inland.

SURFACE FEATURES

TOPOGRAPHY

Other geologists who have visited Panay recognize two cordilleras on this island; one running north and south near and parallel to the western coast, the other branching from the middle of the first and running to the northeast corner of the island. The latter is not considered a cordillera in the strict sense, but this detail has no particular bearing on the present discussion.

The area under consideration is located on the eastern side of the north end of the first cordillera, or cordillera proper. In order to make its outlay clearly comprehensible it may be conveniently divided into three zones; the lowlands, the foothills, and the mountain front.

The lowlands occupy an area from 1 to 4 kilometers wide bordering the coast. It is made up of the deltas of the Makato, Aklan, Cailojan, and other less-important rivers; the sandbars between them; the swamps or the more or less completely filled estuaries behind the sandbars; and the alluvial plain immediately behind the swamps. The shore line is formed by the deltas and sand bars, except where Sigat and Apga Points project cliffs of sedimentary and igneous rocks.

The foothills of the intermediate topography form a wedge-shaped area pointing northwest to Sigat Point. They consist of sedimentary elevations ranging in type from sharp ridges adjacent to the mountain front to low smoothly rolling hills towards the lowlands. The highest elevation is that of Lumati Hill, which is 120 meters, and the maximum relief is about 75 meters. Except those next to the mountain front, the hills are separated by flat-bottomed valleys which form natural rice paddies and over these the creeks often spread in the form of washes instead of cutting narrow channels. In order to control the flow and distribution of water the farmers have built dirt dikes across these valleys, which become spotted with numerous small lagoons during the rainy season.

The mountain front is the eastern edge of the cordillera proper. It is marked by cliffs and steep mountain sides forming a natural and a strongly pronounced boundary between the sedimentary hills of the intermediate topography and the cordillera proper. The mountain front and the cordillera proper consist of igneous rocks, which form the backbone of Panay Island.

Some specially noteworthy features in the intermediate topography are the isolated prominences; namely, Tigayon, Malinao, and Mandoyog Hills. Tigayon Hill is located on the east bank of Aklan River, 1.5 kilometers northwest of Tigayon settlement. It is 20 meters high and 50 meters in diameter with a shape and an isolation that suggest an ancient burial mound. In fact, however, it is a solid block of massive limestone surrounded by quaternary alluvium. On the east side of the hill is a cave on the ground level, about the size of an ordinary room. Mandoyog Hill is located immediately south of Banga, and Malinao Hill is northeast of Malinao. They are cone-shaped and a little over 100 meters high. They are not entirely isolated but stand out sharply in contrast with the long and narrow little elevations that branch off from them. The branch from Malinao Hill extends northeast to about 1 kilometer beyond Lezo, and the branch from Mandoyog extends in the same direction and terminates at Magobinlod Hill. Unlike the other hills of the intermediate topography, Malinao and Mandoyog Hills consist of igneous rocks, mostly andesite.

DRAINAGE

The drainage system here is composed of Aklan, Tangalan, Makato, Cailojan, and Jal-o Rivers. The Aklan is the largest and longest of these. It rises from far in the interior of the

island, in the conjunction of the main cordillera and its eastern branch. The general course of this river is north, but on reaching the intermediate topography at Malinao the low and narrow elevation, already described above extending from Malinao to Lezo, has shifted it to the northeast. Beyond the end of the narrow elevation Aklan River resumes its original northward course and proceeds meanderingly to the sea.

Aklan River has numerous tributaries, most of which come from the cordillera to the west. The first one south from the mouth is Mahabang Tubig, which rises from the igneous cordillera. Above San Roque its course is controlled by the jointing of the igneous rocks, while below it flows northeast following the general slope of the country for about 2 kilometers and then bends to the southeast to empty at right angles into Aklan River. This sharp bend is suggestive of a fault of a southeast strike passing through Malinao and controlling the lower course of Mahabang Sapa.

Next in size to the Aklan is Tangalan River. It rises from the igneous wilderness west of the mountain front and follows a northerly course, probably along a sedimentary-igneous contact up to Panayacan. Here it turns abruptly north 70° east, following the strike of a fault of the same direction. This river is navigable by canoes as far as Panayacan.

Makato River has two main branches, one passing by Agbagogo and the other by Libang. Both of them rise from the mountain front, the Libang branch interning farther up the mountain than the Agbagogo branch. They have sinuous northeasterly courses following the general slope of the country for a short distance beyond Agbagogo and Cayanguan, and thence turn northward to join beyond Makato. Farther down, the river divides into two distributaries, one flowing northeast to Alibugan River and the other northwest, which unite again before emptying into the sea. The northwest distributary is connected with the swampy Dungon River, which is also a common distributary of Makato and Tangalan Rivers.

Cailojan and Jal-o Rivers, rise from the hills west of the Balete Road. They have a general northeasterly course and split into various anastomosing distributaries before emptying into Banga Bay.

Banga Bay is separated from the sea by sand bars. There is no doubt that this shallow body of water will ultimately be silted up with sediments from the various affluent rivers and will form an alluvial plain in the same manner as the alluvial plains east

of the foothills have been built. This process of refilling is going on also in the swampy area between Makato and Tangalan.

VEGETATION

Three types of vegetation may be recognized in this area; namely, the mangrove, the grass, and the forest.

The mangrove thrives in the swamps behind the sand bars, along the margin of Banga Bay, and on the banks near the mouths of the rivers within the reach of salt water.

The grass thrives in the lowlands and on the sedimentary hills of the intermediate topography, while the forests are generally found in the igneous country. This distribution of the grass and the forest vegetation does not correspond naturally to the nature of the soil or the underlying formations but to human activity and indirectly to the topography. The sedimentary area of the intermediate topography, which is easily accessible, has been cleared of forests by transitory farmers, who have thus transformed the country into vast cogon-covered patches. On the other hand the igneous country, which is severely broken and unarable, especially the mountain front, has not been subjected to this devastating process and its virgin forest has remained almost intact. The result is a very pronounced change of vegetation corresponding apparently to the change in the nature of the underlying rock formation. This does not hold true always, however, since farther in the interior there are patches of grassland on igneous formations where the mountain people, like their brethren along the coast, resort to the *cañiñ* system of farming. Likewise, some very steep sedimentary hills west of Balete are also covered with forest.

The conglomerate hills have a peculiar way of responding to the growth of the grass. It is usually scanty and arranged noticeably in rows following the stratification of the beds. This is nicely illustrated in the hills west of Pudiot and north of Tandog.

GEOLOGY

STRATIGRAPHY

The formations that have been found in this area are tabulated and provisionally classified below. For comparison we have included the stratigraphic column of central Panay by A. D. Alvir,¹ who made a geological study of that area in the summer of 1927. We are also adopting his tentative stratigraphic classifi-

¹ *Philip. Journ. Sci.* 42 (1930) 443.

cation in order to minimize confusion, in as much as we have not found enough fossils to determine the exact geological age of the formations.

TABLE 1.—*Age, formation, and composition of northwestern Capiz and central Panay.*

Northwestern Capiz.			Central Panay.	
Age.	Formation.	Composition.	Formation.	Composition.
Quaternary-----	Alluvium-----	-----	Alluvium-----	80 meters.
	Not present-----	-----	Guadalupe tuff.	Tuff, tuffaceous sandstones, tuffaceous shales; 100 meters.
Tertiary-----	(Pliocene-----			
	Not present-----	-----	Malumbang limestones.	Coral reefs; 150 meters.
	(Malinao and Mandayog andesites.	-----	Lavas and Mount Paning Raon intrusives.	
	Miocene-----		Badbaran formation.	Shales, sandstones, limestones; 700 to 800 meters.
	Makato formation.	Sandstones, shales; 500 meters.	Binanganon limestones.	Limestones, shales, sandstones.
	(Oligocene-----			
	Tigayon limestones.	Limestones, sandstones; 150 meters.		
	Campo Verde conglomerates	Conglomerates, sandstones, lignite; 175 meters.	Coal measures.	Sandstones, shales, lignite; conglomerates; 270 meters.
Pretertiary-----	Gabbro, serpentines.	-----	Igneous and metamorphics.	

THE PRETERTIARY IGNEOUS AND METAMORPHIC ROCKS

The pretertiary igneous and metamorphic rocks are the most extensively distributed rocks in this area since they form the mountain front and the bulk of the mountains of the cordillera proper. They show evidence of frequent faulting and pronounced folding and fracturing, especially along the contact with the sedimentary beds. The igneous consist of gray, medium-grained, and holocrystalline gabbro intruded by thin sheets or dikes of the same rock of lighter color and coarser texture, and also of white and dense quartz and anorthosite (samples 22, 23, and 24). Diorite phases are encountered in a few places (sample 60).

The metamorphic rocks are serpentine and schists. The serpentine is dark green, dense, and in places highly kaolinized. In a manner parallel to that of the gabbro, the serpentine is intruded with thin sheets or dikes of the same composition but of a lighter color and a coarser texture (sample 11). Some of the dikes consist of nodules of serpentine embedded in a ground mass of kaolin. The serpentine is found mostly along the mountain front in contact with the conglomerates.

The schists are essentially chlorite, green in color and altering to clay. They are associated with the serpentine along the zone of faulting in the igneous area in the vicinity of Rosario.

The analyses of a few of the specimens by Leopoldo F. Abad, of the Bureau of Science, are included at the end of this report.

THE CHERT FLOATS

Fragments or floats of chert were found 2 kilometers south of Sigkay and along the creeks southwest of Rosario. They are dense and red, similar to those found elsewhere in the Philippines and presumed to be of the Jurassic period. We have not been able to find the source and associations of the chert floats, so their age does not give us a clue to the determination of the ages of the other rocks.

THE CAMPO VERDE CONGLOMERATES (COAL MEASURES)

The Campo Verde conglomerates are associated with sandstones, the conglomerates occupying the lowest place and lying directly on the basal igneous. The conglomerate beds are massive, showing only hints of stratification in isolated outcrops. They consist of gabbro and serpentine pebbles, ranging from 2 to 15 centimeters in diameter, cemented with a matrix of brown and coarse sand or green to dark green weathered serpentine. The finer pebbles are well rounded and are found in the upper beds, while the larger ones are semiangular and found in the lower beds. Occasionally, unusually large and angular pebbles are scattered haphazardly in the more massive beds in which stratification is absent.

It is not easy to locate exactly the contact between the igneous and the overlying conglomerate beds, as these grade down to a breccia consisting of recemented fragments of the base rock, then to severely fractured and refilled igneous, and finally to solid igneous. This gradual transition can be observed near kilometer 11 of the Campo Verde Road cut and at Jawili Falls, northwest of Tandalan.

The associated sandstones are brown to gray in color, from medium to coarse in texture, and not well consolidated. They are usually massive, but sometimes very thin, barely enough to mark the bedding planes of the conglomerate beds. Some of the thick beds contain lenses of poorly consolidated conglomerates of 1-centimeter pebbles. Others are shaly and contain fragments of carbonized wood and plant remains of undiscernible features. These carbonized particles are more noticeable in the outcrops in the vicinity of Balete than in the northern area. In Cailojan Creek, west of Balete Road, the sandstone beds that are being quarried for road ballast are so black with those carbonized fragments that they have been mistaken for coal by some people. These black sandstones, however, turn gray on drying, which happened with the samples collected by the writer. The Campo Verde formation is about 175 meters thick.

THE TIGAYON LIMESTONES (BINANGONAN)

The Tigayon limestones are not uniformly distributed and developed. While they are massive and almost without association in Tigayon Hill, they are thinly bedded and intercalated with sandstones in Cailojan Creek. They could not be found northwest of Aklan River, although the formations directly underlying and overlying them are widely exposed.

The limestone members are white to pale pink and gray in color, dense to granular in texture, and contain unidentified Foraminifera. The granular variety contains inclusions of igneous grains. In some beds the limestone forms the matrix of a conglomerate of igneous pebbles of red, brown, and gray color and about 0.5 centimeter in diameter. The sandstone members are well and thinly bedded, ranging in thickness from 1 to 10 centimeters. They are of different shades of gray and brown, pure to shaly, finely grained, and from soft to hard.

Except in Tigayon Hill, the Tigayon formation does not feature prominently in the topography, its maximum thickness being only about 150 meters.

THE MAKATO FORMATION (BADBARAN)

Of all the tertiary sedimentary formations the Makato is the most widely distributed; it forms the hills of the intermediate topography. This formation consists of intercalations of thin and well-stratified sandstones and shales, typical exposures of which can be seen in the road cut near Makato and in Apga Point, north of Tangalan. The sandstones are fine grained,

hard, light gray, and sometimes with a faint banding parallel to the plane of stratification (sample 48). The shale members are pure to sandy, soft, and brown to gray, which weathers to yellow. In some places thin and sandy laminae containing Foraminifera are found in the bedding planes of the shales (sample 33). Good exposures of shales with a few intercalated sandstones are found east of Libang.

This formation has a different thickness according to the section in which it is calculated, but about 500 meters may be taken as a conservative average. The exaggerated thickness obtained in Section B may have been due to a series of small faults which have caused the repetition of the same formation east of Libang.

THE MALINAO AND MANDYOYOG ANDESITES (MOUNT PANING RAON INTRUSIVES)

The andesites occur as elongated intrusions of a northeast direction on either side of Aklan River and as protuberant cone-like prominences in Malinao and Mandoyog. These intrusions have pushed up and exposed the basal conglomerates of the Campo Verde formation which are naturally older. Hence the andesite intrusions have been classified under the Miocene age, although they could be of the later stage of the Oligocene period.

The andesite varies slightly in character in different localities. One type (sample 63) is dark to light gray in color, granular in texture, and contains macrocrystals of hypersthene, vesicules, and vugs with white crystals of zeolite. This type is found at the top of Magabinlod Hill, northeast of Banga. The other type is light gray, fine grained, and hypocrystalline. It is found in Mandoyog Hill immediately south of Banga, in Lezo and Malinao Hills, and on the slopes of Magabinlod Hill. These two types are evidently facies of the same intrusion.

THE QUATERNARY ALLUVIUM

Under the Quaternary alluvium we have grouped together the Pleistocene and the recent sediments as they cannot be differentiated in the field. Moreover, their mutual relation has no particular bearing on the underlying structures.

These sediments consist of sand along the bars, mud and silt in the deltas, sandy and clayey loams in the flood plains, gravel and sand along the river banks, and laterite. The clayey loam of the flood plains and the river valleys is very extensive. This and the mud and silt of the deltas are of high economic importance as they cover the most fertile rice lands. On the other hand, the sand bars are thickly planted with coco trees. The

laterite is of local occurrence, and is found on the eastern slopes of the hills west of Pudiot. It consists of clay with a high percentage of red and orange limonite. Banks or bluffs of this formation are conspicuous from the automobile road near Pudiot.

CORRELATION

Since fossils are scarce we are using the physical characters of the formations as the only criteria for correlating them and for comparing our columnar section with that of central Panay. Since these sections belong to the same geological unit and the distances separating them are small, the use of the physical characters alone as criteria for correlating them is quite satisfactory.

It will be noticed that in our area we found no formation that can be correlated with the Malumbang limestone, which consists of shales and coral reefs, and the Guadalupe tuffs, all of which form prominent features in the topography of central Panay. We have andesite intrusives, which intersect the Oligocene conglomerates and correspond to the Paning Raon intrusives in central Panay, but no lava. The Badbaran formation of central Panay corresponds to our Makato formation in physical characters, except that our Makato formation has no limestone intercalations; and while the shales and sandstones are equally developed in central Panay, the sandstones predominate in the Makato formation. The Binangonan formation of central Panay corresponds to our Tigayon formation, both containing limestone as well as conglomerates; the former, however, is a great deal thicker than the latter and is associated with shales instead of shaly sandstones. Our Campo Verde conglomerates correspond to the Coal Measures of central Panay in every respect, except that the former are not intercalated with limestones.

From the above comparisons it appears that there is a lateral decrease in the development of sedimentation from central Panay towards the north. This is especially true of the Pliocene formations, which are entirely missing in our area. Even here the lateral diminution of deposition can be detected in the distribution of the Tigayon limestone. It is about 270 meters in central Panay, about 150 meters in Balete, 25 in Tigayon, and disappears altogether northwest of Aklan River. The limestone intercalations of the Coal Measures of central Panay likewise disappear from the corresponding Campo Verde formation of our area.

There is also a lateral change in facies, the shales in our area being more sandy than the corresponding formations of central

Panay. There is a hint, therefore, that the source of sedimentation is from the north, or that the sedimentation here occurred in a shallower sea than that in which it took place in central Panay.

DEFORMATION STRUCTURES

Several deformation structures were found in this area, the most important of which are described in the following paragraphs:

THE TANGALAN ANTICLINE

The Tangalan anticline is about 8 kilometers long and 2 to 3 kilometers wide, with an obtuse crest dipping about 35° on either side. It passes through Agpa Point and runs southward to Tangalan and then gradually turns to the east towards Ali-bangon. Beyond this place the anticline is lost in the low lands north of Numancia, but the strikes of the outcrops near Makato suggest that it continues towards Calivo. The crest and the flanks are all in the Makato formation; the sandstones predominate on the crest and the shales on the flanks.

THE TANGALAN FAULT

The Tangalan fault passes through Panayacan and along the lower course of Tangalan River, which it controls. It is 4 kilometers long and has a strike of approximately north 80° east. Its apparent lateral displacement is westward on the south side of the fault, being probably the component of an actual downward displacement.

Two features have been produced by this fault; one is the bend of Tangalan River at Panayacan at almost right angles, and the other is the discontinuity of the topography as well as of the formations across Tangalan River. It can be noticed that the topography and the formations have been pushed westward on the south side of Tangalan River.

THE LIBANG SYNCLINE

The Libang syncline is 6 kilometers long and 3 kilometers wide. It is shallow, and its axis has a sigmoid shape with a general north and south trend. It shows remarkably well in the topography since erosion has not advanced far enough to obliterate the structural trough and the partly rounded hog-backs on the flanks. Its north end abuts against the frontal gabbro, and its southern end terminates in San Roque. It is cut by a large fault on the west flank, which will be described presently, and by a minor one (probably by several others un-

observed) on the east flank. This syncline is traversed by the Libang branch of Makato River.

THE AGBAGOGO FAULT CONTACT

West of Agbagogo there is a fault running approximately north and south along the igneous-sedimentary contact. This fault is evidenced by cliffs and various waterfalls at the heads of the two branches of Agbagogo River. The cliffs are very conspicuous at a distance and can be traced as far north as Tangalan River and as far south as Makato Falls. At this point the fault is no longer along the contact but in the mass of the basal igneous rocks. The displacement is downward on the east side of the fault and maximum towards the south. This difference in displacement explains the difference of the amount of conglomerate beds exposed in different places along the fault. They are well exposed west of Pudiot and missing west of Libang.

THE LUMATI ANTICLINE

The Lumati anticline is located 2.5 kilometers west of Balete. Its axis has a north 10° west direction and passes through Lumati Hill, which is the highest in the vicinity. On the obtuse crest are conglomerates and sandstones of the Campo Verde formation, and on the east flank are Badbaran limestones and sandstones. The east flank terminates in a narrow and shallow syncline; the west flank is not well defined. This anticline may extend farther north than indicated on the map, as the topography suggests, but the writer was unable to examine this end and the west flank on account of unfavorable weather.

The syncline west of Rosario was not actually located in the field, but it is a necessary inference from the adjoining structures on either side. It has a north and south axis, which probably bends to the northwest towards Venturanza.

THE VENTURANZA ANTICLINE

This anticline is 1.5 kilometers long and has a northeast and southwest axis. The crest is dissected by Cailojan River where massive conglomerates of the Campo Verde formation are exposed and dip more steeply on the northwest side than on the opposite side. The northwest flank of this anticline is in Makato shale and sandstones and terminates in a parallel syncline of equal length, while the southeast flank is only 0.5 kilometer wide. Beyond this distance the beds reverse their attitude to form the west flank of a probable anticline lying to the east. The short syncline west of the Venturanza anticline is probably the extension of the one lying east of Rosario.

THE MAHABANG SAPA FAULT

The Mahabang Sapa fault is about 4 kilometers long; it strikes approximately to the northwest and passes through the town of Malinao and along Mahabang Sapa. The lateral displacement is southeast on the northeast side of the fault, as the conglomerate outcrops indicate. This fault is the controlling factor of the lower course of Mahabang Sapa, which it diverted at 2 kilometers northeast of San Roque and deflected in its course from northeast to southeast.

TECTONIC LINES

It will be noticed that except for the Tangalan fault, the Malinao fault, and the Tangalan anticline the deformation structures described above are more or less parallel to two directions; one north 20° west, which is the trend of the gabbro intrusion forming the bulk of the Cordillera proper; and the other northeast, the trend of the andesite intrusion on either side of Aklan River. We may, therefore, consider these two as the major tectonic lines here, the north- 20° -west direction being more prevalent than the other.

The direction of the axis of the Tangalan anticline is not necessarily due to a third direction of tectonic force, but is probably the resultant of the combination of the two major ones. The direction of the Malinao fault, while not in accord with either of the major directions, does not vary radically from the directions of the adjoining anticline and fault to the north. The Tangalan fault remains then the only deformation structure whose direction digresses from that of the two major tectonic lines, and its cause must be considered local.

ECONOMIC GEOLOGY

The writer did not penetrate far enough into the igneous country to give an authoritative account of the mineral possibilities in this territory, but what is certain is that the igneous outcrops, along the rivers and creeks, and the igneous boulders show no mineralization. Reports have been received of the existence of gold in the interior southwest of Malinao, but they are of a legendary color and it is hard to say just how much credit should be given to them.

The reported coal south of Daja, in a place called Pinacasunagan, was found to be black shale; and that 2 kilometers northwest of Balete was found to be black sandstone; the color of both formations is due to minute fragments of carbonized plant remains. Coal was reported to have been found south of Balete,

but this place was not reached by the writer. It is not unlikely that coal might be found here, because the Campo Verde formation, which is coal-bearing elsewhere in the Philippines, is present.

Of actual economic importance are the limestones, sandstones, and gravel, the last two being actually utilized for building purposes. The gravel along the Aklan and other rivers furnishes a cheap material for concrete mixture and road ballast. The black sandstones that are being quarried in the upper Cailojan Creek, previously reported as coal, are also used for road ballast. The limestones of Tigayon Hill may be used for the manufacture of a limited amount of lime.

UNDERGROUND-WATER RESERVOIR

In this area there are two kinds of rocks that may serve as water reservoirs; namely, the conglomerates and the sandstones of the Campo Verde formation. They are both porous and located favorably for intake west of Pudiot, in Lumati Hill, and also, although not extensively, along the Malinao-Lezo hills. Outcrops of these beds have been observed actually oozing water along the Balete Road and in some hills north of Malinao. There are also shaly sandstone beds on the top of the Campo Verde formations that may act as cap rock over the reservoir. One possible drawback, however, is their location at the bottom of the sedimentary formations, which may be too deep to be reached by economic drilling in the very places where artesian wells are needed.

The Tigayon limestone and the sandstones of the Makato formation are not likely to contain water. The limestone beds are not uniformly distributed on the former, and they are not porous or cavernous on the latter. The Makato sandstone beds, on the other hand, are thinly bedded and too dense to contain water.

POSSIBLE SOURCE OF SURFACE-WATER SUPPLY

There are two falls here that may be used as sources of water supply; namely, the Jawili and the Makato Falls.

Jawili Falls is located 0.5 kilometer beyond the head of the Hawili estuary, 3 kilometers northwest of Tangalan. The falls occur over Campo Verde conglomerates and are fed by a perennial creek. At the foot of the falls there are large pot holes or solution holes, which are being used as swimming pools by excursionists that come from the neighboring towns. The head of the falls is about 15 meters high and the water, which

comes from an igneous country, is clear and perhaps is sufficient to supply the town of Tangalan, but not more. The water could be piped to Tangalan easily without going over any hill.

Makato Falls is located over a fault in the igneous formation 2 kilometers southwest of Libang. The head of the falls has an elevation of about 75 meters, and the drop is over 40 meters. The water comes from several small streams, which rise from the igneous country behind the mountain front and unite at a short distance behind the head of the falls. Here the stream has an average width of 2 meters, a depth of 25 centimeters, and a good flow, which insure a good volume of clear water. There is a narrow cañon of solid igneous rocks just behind the falls that would make an ideal dam site, from which the water could be piped over a moderately undulating country following the valley of the Makato River to the neighboring coastal towns of Makato, Calivo, and New Washington.

CONCLUSION AND RECOMMENDATION

CONDITIONS NECESSARY FOR AN ARTESIAN WELL

The object of an artesian well, as it is understood here, is to tap a pool of potable underground water, which may occur in pervious beds of sedimentary rocks or in fissures in igneous rocks. Since there is no accurate method of determining the occurrence of fissures deep in igneous rocks, much less their size, drilling for artesian wells in an igneous country is very uncertain. On the other hand, because of the tabular form of the sedimentary beds whose attitude can be measured accurately, the position and attitude of the reservoir rocks in the sedimentary areas can be calculated approximately, thereby making the scientific location of the artesian well possible. It is, therefore, only the study of the possibilities of artesian wells in the sedimentary area that will be treated here.

In order that the underground water pool in sedimentary rocks may be tapped with a well successfully, it must be confined in a pervious rock called the reservoir rock, lying between two impervious beds, usually of shale or clay. The underlying impervious bed is not always necessary, but there must be an overlying impervious bed or cap rock. Besides, the reservoir bed must be either inclined or folded in the form of a basin or syncline; and in the latter case it must be exposed on either or both flanks so that the water falling on it can accumulate in the basin, or syncline. There are other geologic structures that may give artesian flow, but they are not discussed here

because of their absence in the area studied. If the water in the reservoir is tapped with a well, it will rise to a height proportional to the pressure due to the head of the intake minus the frictional resistance that the reservoir bed offers to the flow of the water.

ARTESIAN-WELL POSSIBILITIES IN THIS AREA

There are good reservoir rocks in this area, as mentioned in a previous section, and they are folded into favorable structures for water accumulation. None of the important communities that need artesian wells is located within these structures, however.

Beginning from the north, Tangalan is located on the crest of the Tangalan anticline, Makato and Numancia are about 1.5 kilometers south of it, while Calivo lies on the crest of its probably eastward extension. It is easy enough to conjecture that the water in the trough of the synclines may rise to the crest of the adjoining anticlines periodically when there is great precipitation on the intake, but this migration of water along the reservoir beds is not certain in this area because of the intervening faults.

Lezo is located on an andesite intrusion, except its northwestern suburb which lies on the very intake of the syncline or trough to the west. Malinao is located on the northwestern flank of the Malinao andesite intrusion where the catchment area is limited; with the additional disadvantage that it is close to the Mahabang Sapa fault, which may intersect the reservoir beds. Banga is similarly located on the northwest flank of the Mandoyog intrusion, where again the conglomerate catchment area is very limited. Balete is located 2 kilometers east of the south end of a small syncline, a distance which places it outside of the trough. New Washington is 9 kilometers from the nearest, exposed, deformation structure, where the nature of the underlying structure is entirely conjectural. Therefore, drilling for structural underground reservoirs cannot be recommended for the above-mentioned communities.

However, these communities are located on or next to good quaternary alluvial deposits of gravel and sand, which are good reservoirs of subsurface water. In the absence of favorable deformation structure, these water-bearing alluvial deposits should be sought in drilling for subsurface wells. Malinao, Banga, Balete, and, possibly, Lezo are especially recommended as they are next to fresh-water streams, which can supply the subsurface

gravel reservoir. Exceptions are made of New Washington, Makato, and Numancia, which are located near sea level, where subsurface water will be contaminated with sea water. Drilling here would be equivalent to drilling in reclaimed land, like the New Luneta, Manila, where salt water certainly would be encountered.

There is a certain feature that must be considered with regard to Calivo. This town is located on the delta of Aklan River, and cases are known of successful artesian wells in similar locations in the Philippines. The water in such a location is tapped from the fresh underflow through buried gravel lenses that are fed from the upper courses of the streams. Considering the importance of Calivo, it is hereby recommended that a test be made on the possible underground gravel lenses.

Tangalan is similarly located. But here, between drilling wells and piping the water from Jawili Falls, the latter is easily the better choice, provided the town can afford it.

In conclusion, drilling for structural artesian wells in the important communities in this area is highly speculative, while drilling on the favorable structures is impractical because of their distance from the communities. Incased subsurface wells in the quaternary gravel are recommended, however, in the immediate vicinity of Lezo, Malinao, Banga, and Balete; and, though less strongly, in Calivo and Tangalan.

Artesian wells, lastly, should be considered only as a temporary measure; and surface sources, such as Makato and Jawili Falls, must ultimately be developed to insure a good and abundant supply of potable water to the coastal towns.

The following petrographic examinations of rocks collected in Capiz Province were made by Mr. Leopoldo F. Abad, mining engineer, Bureau of Science.

Field No. QAA 11.

Rock name, serpentine (from peridotite); collector, Q. A. Abadilla (1929); locality, Agsasawa Creek, Malinao.

Megascopic.—The sample is an altered, fine-grained, amorphouslike ultra-basic rock, intruded by a one-inch dike of a similarly altered, mottled with porphyritic-effect, less basic rock.

Microscopic.—Under the microscope the intruded rock has a mesh fabric showing an almost complete serpentinization of the original rock. A few grains of olivine remain unaltered. The dike is also almost completely altered, with the ferromagnesian

minerals changing into mesh-textured serpentine as that of the intruded rock embedded in amorphous kaolinite.

Minerals.—The intruded rock is chiefly serpentine with grains of chromite and magnetite, some chlorite, and a few grains of unaltered olivine. The dike contains serpentine, some peroxene minerals, olivine, bastite, magnetite, chromite, and kaolinite.

Remarks.—The dike is less basic, and appears to be a later injection of the same magma from which the peridotite was first differentiated. The embedding mass consists of kaolinite resulting from the alteration of the original feldspar. Therefore, it is probable that, with the accessory minerals found, the dike was originally an olivine-gabbro.

Field No. QAA 23.

Rock name, gabbro; collector, Q. A. Abadilla (1929); locality, San Roque Barrio, Malinao.

Megascopic.—The sample is a phanerocrystalline, dark gray, melanocratic, medium to coarse-grained rock.

Microscopic.—Under the microscope it has a seriate intersertal semiophitic fabric.

Minerals.—The essential mineral is labradorite. The accessory minerals consist of augite, diallage, and ilmenite. The secondary minerals are magnetite, bastite, rutile, limonite, and chalcedony (veinlet fillings).

Field No. QAA 60.

Rock name, quartz-diorite (altered); collector, Q. A. Abadilla (1929); locality, Venturanza-Sigkay Road, Banga.

Megascopic.—The sample consists of residual angular pebbles of a partly weathered, grayish white, medium-grained rock.

Microscopic.—Microscopically it is holocrystalline, inequigranular, hiatal with porphyritic effect. The phenocrysts are single and groups of anhedral and euhedral quartz, and some tabular feldspars. The original ferromagnesian minerals are not found, but have probably all changed into chlorite which are found in irregular shapes and almost invariably contain included or attached grains of magnetite. The groundmass is micrographic.

Minerals.—The essential minerals are quartz and feldspar of the andesine-oligoclase series. The secondary minerals are chlorite, few magnetite grains (some cubic), and kaolin.

Field No. QAA 62.

Rock name, augite-andesite; collector, Q. A. Abadilla (1929); locality, Mandoyog Hill, Banga.

Megascopic.—The sample is a gray, vesicular, hypocrystalline rock. Some pores contain fillings of limonite and zeolites.

Microscopic.—Under the microscope the fabric is docrystalline, porphyritic dosemic. The phenocrysts consist of subhedral and euhedral tabular plagioclase crystals and euhedral pyroxene minerals in diverse arrangement. The pyroxenes invariably contain some attached grains of magnetite. Some plagioclase phenocrysts show zonal structure. The groundmass is felsophyric.

Minerals.—The essential mineral consists of plagioclase of the andesine-labradorite series. The accessories are augite, enstatite, and apatite. The secondary minerals are magnetite, urallite, bastite, and kaolin.

Field No. QAA 63.

Rock name, hypersthene-andesite-porphyry; collector, Q. A. Abadilla (1929); locality, Magabinlod Hills, Banga.

Megascopic.—The sample is light to dark green, vesicular, porphyritic with few megaphenocrysts of large, prominent, and well-developed crystals of orthorhombic pyroxene. Some vesicles are filled with secondary calcite and zeolites.

Microscopic.—Under the microscope the fabric is hypocrystalline porphyritic perpatitic. The phenocrysts consist of anhedral and subhedral tabular crystals of plagioclase in diverse arrangement, some euhedral pyroxene minerals and grains of magnetite. A few crystals of plagioclase show zonal structure under cross nichols. The groundmass is felsophyric and shows slight alteration.

Minerals.—The essential mineral consists of feldspar of the andesine-labradorite series. The accessories are hypersthene and augite. The secondary minerals are magnetite, limonite, and kaolin. The secondary calcite and zeolites are found in vesicles.

Remarks.—Some of the hypersthene crystals measure more than 10 millimeters in diameter.

ILLUSTRATIONS

PLATE 1

- FIG. 1. Sandstone beds at kilometer 98 of road west of Makato.
2. Subuk Mountain, the broken cone in the background. This mountain is made up of sandstones and massive conglomerates.
 3. Tigayon Hill, on the east bank of Aklan River 4 kilometers south of Calivo. This is an isolated hill of limestone. View from Parian Hill across Aklan River, 1.5 kilometers northeast from Lezo.

PLATE 2

- FIG. 1. Calimbahan River and Valley. The valley is characteristic in the tertiary sedimentaries; wide and U-shaped.
2. The outer fringes of the hills bordering the quaternary alluvium. Note the abrupt end of the hill on the left third of the picture, facing the coast, suggestive of wave cutting. In the foreground is the Capiz provincial road between Makato and Pudiot Barrio.
 3. Horizontal shale and sandstone beds, 2 kilometers northwest along the road from Balete. A normal fault of about 1 meter displacement shows on the left third of the picture.

PLATE 3

Looking down from above the head of Makato Falls. Note the narrow cañon. From this point to the foot of the falls there is a drop of about 60 meters.

PLATE 4

Makato Falls, 1 kilometer west of Libang. Drop of falls in sight is about 40 meters. This is the source of the proposed water supply for Calivo and neighboring towns.

PLATE 5

- FIG. 1. Panoramic view of western Capiz, taken from 1 kilometer north of Libang. The thickly wooded mountains to the left are igneous. The grass-covered hills are tertiary sedimentaries. The flats to the right bordering the coast are quaternary alluvium.
2. Panoramic view of western Capiz Province, taken 1 kilometer east of Subuk Mountain, looking to the east. The last mountain to the right in the background is igneous. The next mountain, which is conical in profile section, is made up of sandstones and shales. These are the lower strata of the tertiary sedimentaries which form the low hills farther west, or in the middle background. The flat area is made up of coastal plain, delta, and sand bars.

PLATE 6

- FIG. 1. Panoramic view of western Capiz Province, taken 2 kilometers north of San Roque, looking northward to the coast.

- FIG. 2. Panoramic view of western Capiz, from Lumati Mountain. The hills in the foreground are tertiary sedimentaries and the flats in the background towards the coasts are quaternary alluvium. The village of Balete can be seen in the right third of the picture.

PLATE 7

- FIG. 1. Rock specimen QAA 11; natural size.
2. Section of rock specimen QAA 11; $\times 82$.

PLATE 8

- FIG. 1. Section of rock specimen QAA 23; $\times 82$.
2. Section of rock specimen QAA 62; $\times 82$.

PLATE 9

- FIG. 1. Rock specimen QAA 63; natural size.
2. Section of rock specimen QAA 63; $\times 82$.

PLATE 10

Geologic map of northwestern Capiz Province, Panay, comprising the municipalities of Banga, Calivo, Makato, Malinao, and New Washington.



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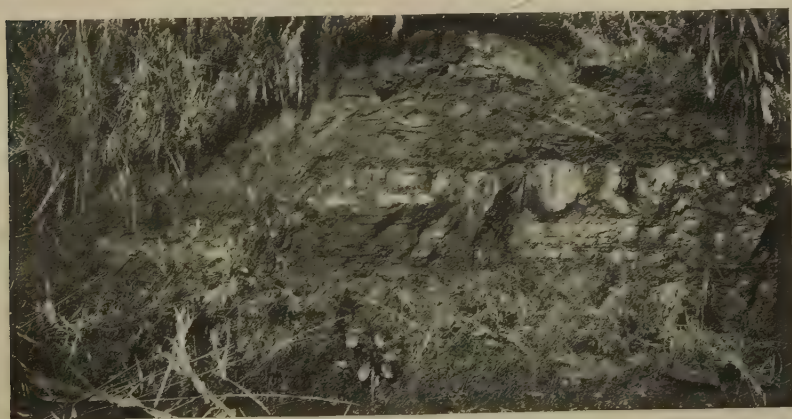
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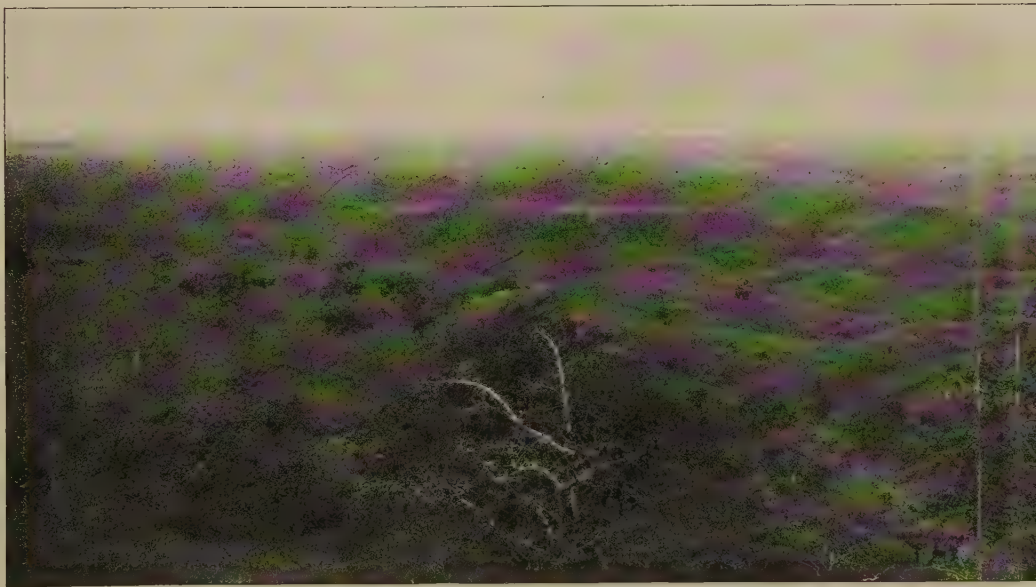
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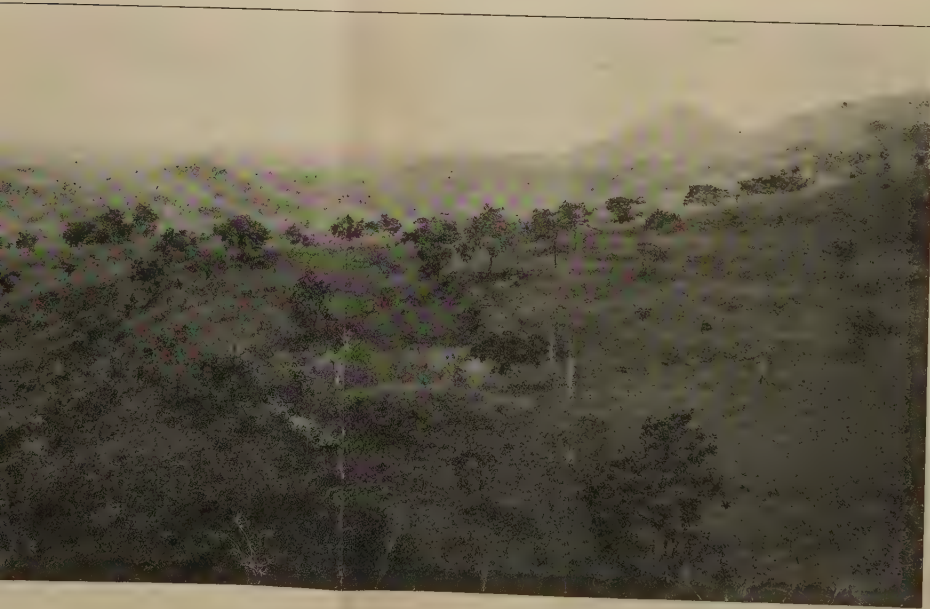
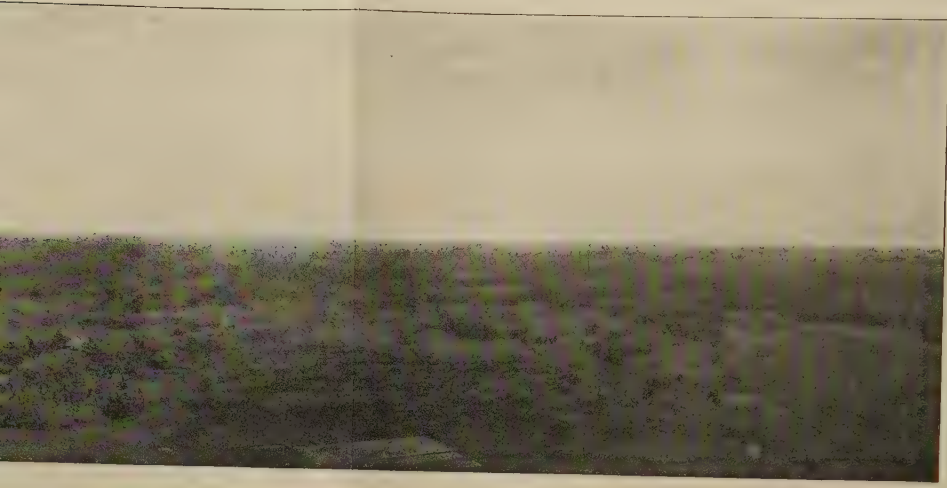


PLATE 3.

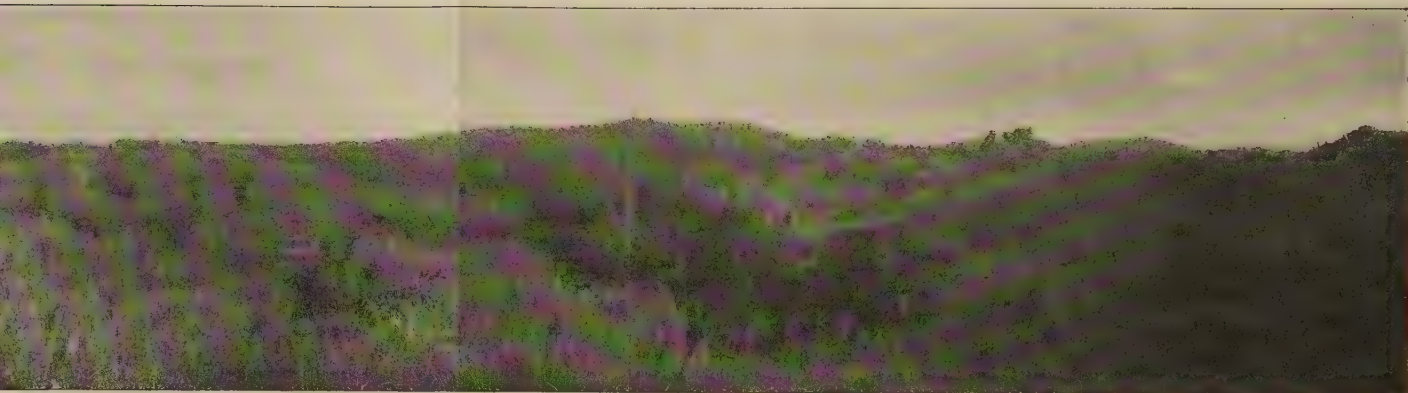


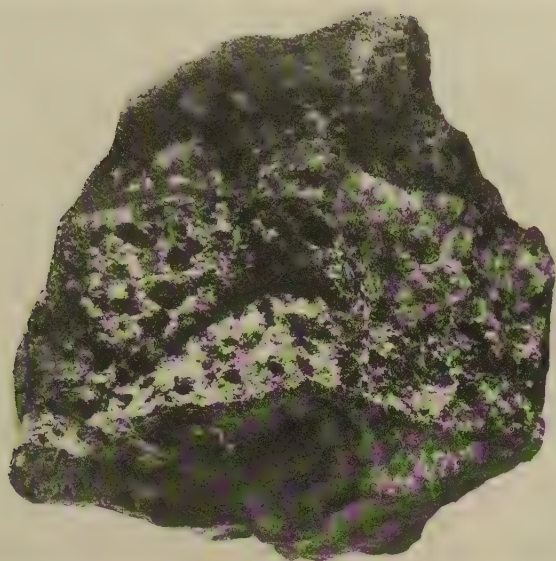
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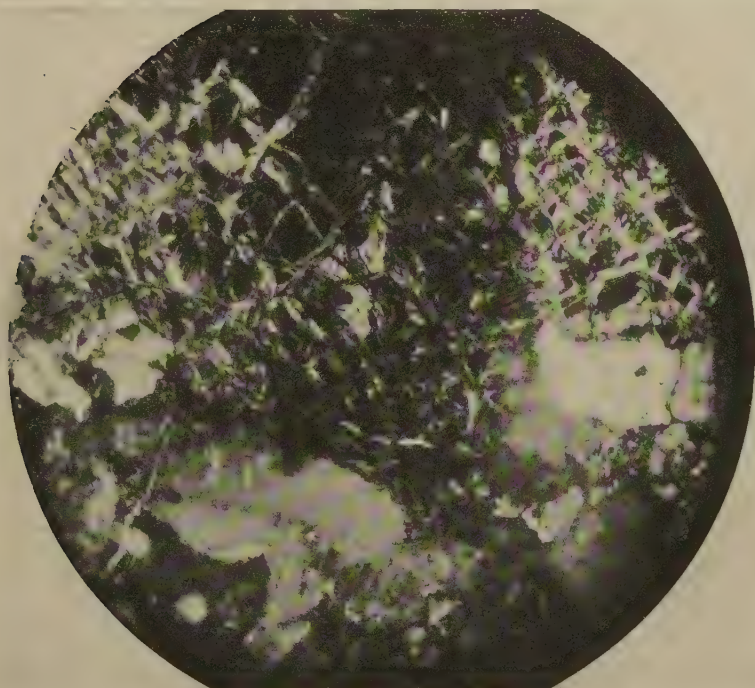






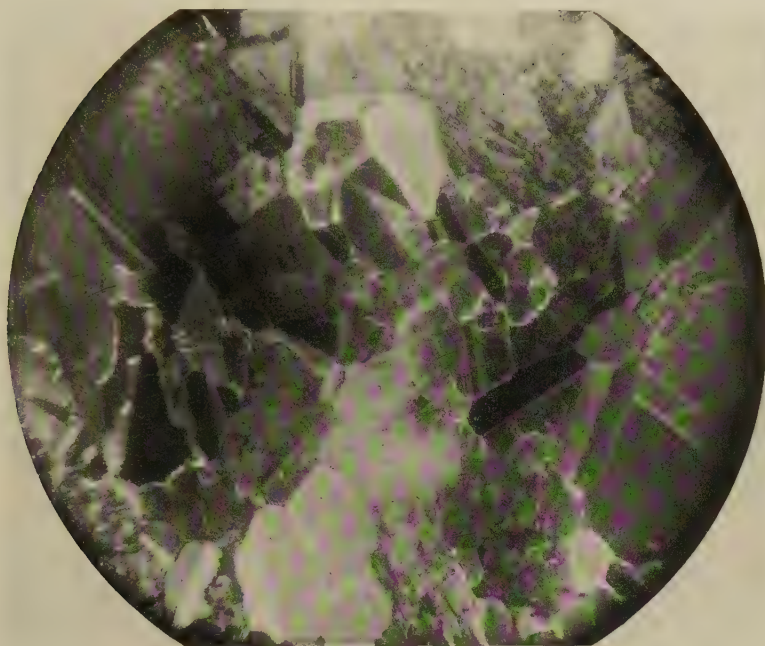


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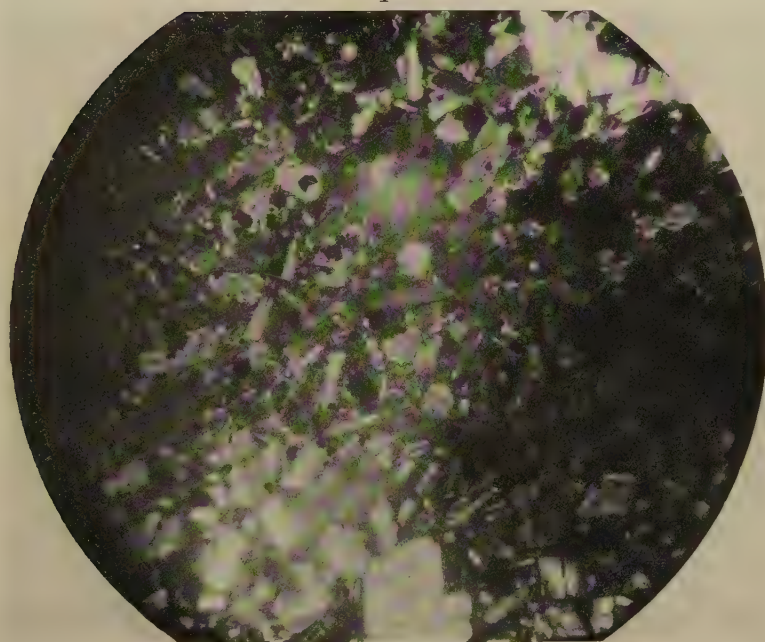


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PLATE 7.



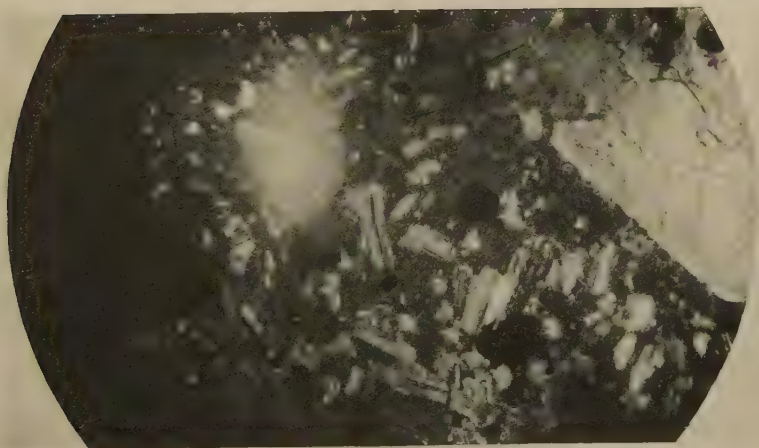
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NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), IX ¹

By CHARLES P. ALEXANDER

Of Amherst, Massachusetts

THREE PLATES

The crane flies discussed in the present report are chiefly from the La Lun Mountains, Davao district, Mindanao, Philippine Islands, where they were collected at altitudes of between 5,500 and 5,800 feet, by Mr. Charles F. Clagg. A few of the species described from Mindanao were also found to occur in Luzon, where they were taken by Messrs. McGregor and Rivera. I wish to thank the above gentlemen for their kind coöperation in this study of the tipulid fauna of the Philippines and for the privilege of retaining the types of the novelties described in my collection.

TIPULINÆ

SCAMBONEURA MINDANAOENSIS sp. nov. Plate 1, fig. 1; Plate 2, fig. 23.

General coloration yellow, the præscutum with three metallic black stripes; vertex with a dark median vitta; antennæ (male) relatively short; wings with the elements of the anterior cord in nearly transverse alignment; male hypopygium with the outer dististyle a long yellow rod that terminates in a blackened spinous point; appendage of ninth sternite a long slender orange rod.

Male.—Length, about 13 to 14 millimeters; wing, 12.5 to 15; antennæ, 3.

Female.—Length, about 16 millimeters; wing, 15.

Frontal prolongation of head orange yellow, with a narrow black dorsomedian line; nasus elongate, black; palpi obscure yellow, passing into black outwardly. Antennæ relatively short in both sexes; scape yellow; flagellum (male) black; (female) black, in cases with the incisures of the basal segments restrictedly yellow. Head obscure orange yellow to brownish yellow, with a conspicuous brown line on vertex, this narrower in female.

¹ Contribution from the entomological laboratory, Massachusetts Agricultural College.

Pronotum black, the broad central portion of the posterior notum yellow. Mesonotal præscutum yellow with three black stripes, with greenish reflections in male, more purplish in female; scutal lobes with the entire lobes similarly darkened; median region of scutum light yellow; scutellum darkened, light yellow at base; postnotal mediotergite light yellow, with darkening at both base and apex. Pleura yellow, vaguely marked with more reddish brown. Halteres obscure yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow; femora obscure yellow, the tips blackened; tibiæ and tarsi passing into black. Wings (Plate 1, fig. 1) hyaline, iridescent; stigma brown; veins black, paler in the costal region. Venation: Rs and other elements of anterior cord in oblique to transverse alignment, cell R_3 lying more basad than cell R_5 ; R_{1+2} represented by a conspicuous spur that is subequal to or longer than R_2 ; forks of media deep; m-cu close to fork of M.

Abdominal tergites orange, each with a conspicuous blue-black area occupying the center of the disk, the pale apex of the segment a little narrower than the base; on outer segments the dark areas are more extensive, occupying most of the segments; sternites obscure yellow; hypopygium chiefly darkened, the styli and appendage of the ninth sternite yellow or orange. Male hypopygium (Plate 2, fig. 23) large and conspicuous. Ninth tergite, *9t*, without heavy chitinization, the obtuse lateral lobes separated by U-shaped notch, set with short black spines and spinous setæ. Outer dististyle, *od*, a long projecting yellow rod, terminating in a blackened tip. Inner dististyle, *id*, considerably shorter, shaped as in figure. Conspicuous blackened bispinous structures that may be gonapophyses on either side of median line. Appendage of ninth sternite, *9s*, a long, feebly sinuous, slender rod that is only slightly expanded at apex, directed caudad, the tip slightly more dorsad, the surface densely covered with short setulæ.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 6 males and females. "Sweeping among ferns and undergrowth along margins of brook."

Scamboneura mindanaoensis is most closely related to *S. primæva* Alexander (Luzon), differing especially in details of venation and coloration of the præscutum. The male of *primæva* is still unknown.

SCAMBONEURA DAVAOENSIS sp. nov. Plate 2, figs. 24, 25, and 26.

General coloration yellow; antennæ (male) elongate; præscutum with three leaden stripes that are conspicuously bordered by velvety black; a median dark area on postnotal mediotergite; wings with anterior cord strongly bowed; male hypopygium with the tergite produced medially; outer dististyle a short and broad ear-shaped lobe; appendage of ninth sternite short and broad.

Male.—Length, about 14 millimeters; wing, 12; antennæ, about 5.5.

Female.—Length, about 18 millimeters; wing, 15.

Frontal prolongation of head yellow, weakly infuscated dorsally; nasus black; palpi obscure yellow, the terminal segment blackened. Antennæ (male, elongate; scape brownish yellow; flagellum black, the apices of the basal segments restrictedly obscure yellow; female with antennæ shorter, the bicolorous nature more conspicuous. Head obscure yellow, the occipital region and a line therefrom onto vertex brownish black.

Pronotum blackened laterally, yellowish white medially. Mesonotal præscutum yellow, with three leaden stripes that are conspicuously bordered by velvety black; lateral margins of sclerite and a spot laterad of anterior end of lateral stripe blackened; scutum yellow, the lobes conspicuously blackened; scutellum brownish black, the base more yellow; parascutella black, their anterior margin yellow; postnotal mediotergite yellow, a median line and the posterior margin blackened. Pleura yellow, variegated with brown and reddish brown. Halteres blackened. Legs with the coxæ and trochanters yellow; femora obscure yellow, narrowly infuscated at tips; tibiæ brownish yellow, the tips narrowly blackened; tarsi black. Wings subhyaline, iridescent; stigma pale brown; veins black. Macrotrichia of veins elongate. Venation: Elements of anterior cord strongly bowed, as in the other specialized members of the genus; forks of medial field deep.

Abdominal tergites dull orange, the disk of each with a blue-black area, this becoming more extensive on the outer segments; lateral margins of tergite darkened; hypopygium blackened. Male hypopygium small. Ninth tergite (Plate 2, fig. 24) with the median area further produced, with a small V-shaped median notch. Outer dististyle, *od* (Plate 2, fig. 25), a short, broad, ear-shaped lobe. Inner dististyle, *id* (Plate 2, fig. 25), unusually small, heavily blackened. Appendage of ninth sternite, 9s

(Plate 2, fig. 26), a short broad lobe, the lateral angles with coarse setæ, these becoming shorter and less conspicuous toward the obtuse apex of the lobe.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratype, male. "Among ferns and mossy trees."

Scamboneura davaoensis is most closely related to *S. dotata* Osten Sacken (Luzon), from which it differs in the longer and more nearly uniformly blackened antennæ of the male and the details of structure of the hypopygium, notably of the tergite.

DOLICHOPEZA (NESOPEZA) SPINISTERNATA sp. nov. Plate 1, fig. 2; Plate 2, fig. 27.

Belongs to the *gracilis* group; closely allied to *gracilis* de Meijere; general coloration yellow; antennæ elongate, pale yellow; mesonotal præscutum with three very poorly indicated pale brown stripes; pleura yellow; femoral tips weakly darkened; wing pattern much as in *gracilis*, the costal darkening not including cell R_3 ; medial forks of moderate depth; male hypopygium with each lateral angle of the sternite produced into a powerful spine that is composed of fasciculate black bristles.

Male.—Length, about 8 millimeters; wing, 8.5; antennæ, about 3.8.

Rostrum and palpi black. Antennæ (male) elongate, as shown by the measurements; yellow, the outer segments a very little darkened; flagellar segments elongate-cylindrical. Head brownish gray, narrowly clearer gray on the orbits; anterior vertex about three times as wide as the first scapal segment.

Mesonotum yellow, the præscutum with very poorly indicated pale brown stripes; scutal lobes with similar scarcely indicated markings; scutellum and postnotum more testaceous. Pleura pale yellow, unmarked. Halteres yellow, the knobs infuscated. Legs with the coxæ and trochanters pale yellow; femora yellow, the tips broadly but weakly darkened; tibiæ yellowish white, the tips narrowly blackened; tarsi white. Wings (Plate 1, fig. 2) whitish subhyaline, with a brown, chiefly costal, pattern that is arranged much as in *gracilis*; costal darkening ending at vein R_3 , cell R_3 being entirely clear; pale area in cell Sc_2 very extensive, the darkened portions restricted to the ends of the cell. Venation: Forks of medial field of moderate depth; cell 2d A relatively wide.

Abdominal tergites obscure yellow, the caudal margins of the basal segments weakly darkened, the outer segments more extensively so; sternites chiefly yellow, the caudal margins very

narrowly to scarcely darkened; hypopygium brownish yellow. Male hypopygium (Plate 2, fig. 27) with the lateral arms of the tergite, 9t, blackened, obtuse, provided with a few small black spinous points. Lateral angles of the sternite, 9s, produced into a powerful spine comprised of groups of fasciculate black setæ; median region of sternite at margin with further conspicuous black setæ. Outer dististyle a very small pale lobe, about as long as the beak of the inner dististyle.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 4, 1930, by sweeping (*Clagg*); holotype, male.

DOLICHOPEZA (NESOPEZA) PAUCISPINOSA sp. nov. Plate 2, fig. 28.

Belongs to the *gracilis* group; closely allied to *gracilis* de Meijere; mesonotal præscutum and pleura distinctly patterned with dark brown; wings light gray, with a heavy costal pattern; medial forks deeper than in *gracilis*; male hypopygium with the spines of the sternite relatively few in number.

Male.—Length, about 8.5 millimeters; wing, 9.5.

Female.—Length, about 9.5 millimeters; wing, 9.5.

Rostrum and palpi black. Antennæ with the basal segments obscure yellow, the flagellar segments passing into brown. Head gray, with a transverse brown marking connecting the eyes on the posterior vertex.

Mesonotal præscutum whitish, the median stripe dark brown, conspicuous; lateral stripes less evidently defined; scutum whitish, each lobe with two confluent brown marks; scutellum and posnotum pale brown. Pleura pale, variegated with dark brown on the anepisternum, ventral sternopleurite, meron, and narrowly on the ventral pleurotergite. Halteres with the stem dusky, the extreme base pale yellow, the knobs blackened. Legs with the coxæ and trochanters pale yellow; femora yellow, the tips conspicuously brown, the proximal half of this ring more intense, blackened; tibiæ whitish yellow, the tips narrowly darkened; tarsi white. Wings light gray, with a conspicuous dark brown costal pattern, arranged as in *gracilis*; two isolated whitish spots beyond the solid costal darkening, the first occupying the distal three-fifths of cell Sc₂, the second the outer end of cell R₃; dark seams at origin of Rs and in proximal end of cell R narrower than in *gracilis*. Venation: Distal end of vein R₃ strongly upcurved, widening cell R₃; medial forks deeper than in *gracilis*, the petioles of the cells correspondingly shortened; cell 2d A narrow.

Abdominal tergites dark brown, the basal segments variegated laterally with pale before their ends, the amount of dark color-

ing increasing outwardly; hypopygium chiefly dark. Male hypopygium (Plate 2, fig. 28) with the tergite, 9t, blackened, the lateral arms obtuse at tips, each provided with about fifteen small tubercles; median region of tergite weakly produced. Outer dististyle, *od*, short and stout. Sternite, 9s, with the spines large and conspicuous but reduced in number, there being about five or six on the lateral lobes, of which three or four are on the lateral portion, the others, shorter and stouter, on the mesial portion; median lobe of sternite with about eight spines, there being about four on each lateral angle.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 2 to 3, 1930, by sweeping (*Clagg*); holotype, male; allotype, female.

The female is much darker than the male but seems undoubtedly to be conspecific. The dark markings of the thorax are more intense and contrast strongly with the ground color.

LIMONIINÆ

LIMONIINI

LIMONIA (LIMONIA) CLAGGI *sp. nov.* Plate 1, fig. 3; Plate 2, fig. 29.

General coloration black; anterior vertex silvery; præscutal stripes and centers of scutal lobes brownish yellow; legs black, the tips of the tibiæ and the tarsi paling to yellow; tarsal claws edentate; wings dusky, with a heavy dark brown pattern that is bordered by cream-colored areas; *Sc* long, *Sc*₁ extending to beyond *r-m*; *Rs* short, strongly angulated at origin; *m-cu* beyond fork of *M*; anal veins strongly curved to the wing margin; male hypopygium with the rostral prolongation long and slender, expanded at apex, provided with a single black spine; at base of prolongation from face of style a long pale basal tubercle tipped with a black spine.

Male.—Length, about 7.5 millimeters; wing, 8.5.

Rostrum dark brown; palpi black. Antennæ black; flagellar segments long-oval, with short glabrous apical necks; segments densely clothed with black setulæ and additional verticils, the longest of the latter unilaterally arranged and slightly exceeding the segments. Head black, the front and anterior vertex silvery; anterior vertex narrower than the diameter of the scape.

Pronotum dark brown. Mesonotal præscutum black, the usual stripes brownish yellow; scutal lobes with brownish yellow centers, the borders black; scutellum and postnotal mediotergite dark brown to black, sparsely pruinose. Pleura black, the sternopleurite paler, brown. Halteres with the stem yellow, infus-

cated on middle half, the knobs dark brown. Legs with the coxæ yellow, the mid-coxæ darker; trochanters obscure yellow; femora brownish black, the bases restrictedly paler; genua very narrowly and indistinctly brightened; tibiæ black, the extreme tips paling to yellowish; tarsi yellow, the terminal segments darkened; claws (male) long and slender, edentate. Wings (Plate 1, fig. 3) suffused with dusky, with a heavy brown pattern that is bordered by cream-colored areas; a very extensive brown costal area extends from before Rs to beyond the fork of Sc; other major dark areas as follows: At h and arculus; R_2 and R_{1+2} ; center of cell R_2 at margin; tips of veins R_3 , R_{4+5} , Cu_1 , and the anal veins; a series of three spots, one each in cells R_5 , $2d M_2$, and M_3 , in a line that parallels the wing margin; conspicuous seams on cord and outer end to cell 1st M_2 ; veins brown; outer portion of costa more incrassated, brownish black, with four conspicuous yellow areas, the first in cell Sc_1 , two in cell R_2 , the last, smallest, in cell R_3 . Venation: Sc long, Sc_1 ending beyond r-m, Sc_2 at its tip; Rs short, very strongly angulated at origin; basal section of R_{4+5} nearly as long as Rs; cell 1st M_2 closed; m-cu about one-half its length beyond the fork of M, a trifle longer than the distal section of Cu_1 ; anal veins curved strongly to the wing margin.

Abdominal tergites brownish black, the sternites with a broad obscure yellow basal triangle; hypopygium dark. Male hypopygium (Plate 2, fig. 29) with the caudal margin of the tergite, 9t, very gently emarginate. Basistyle, *b*, of moderate size, the ventromesal lobe obtuse, basal in position. Dorsal dististyle a nearly straight rod, the curved apex blackened, the outer margin with abundant appressed spinulæ. Ventral dististyle, *vd*, oval, with conspicuous setæ; rostral prolongation long and slender, at apex more expanded, on outer margin with a black spine; at base of prolongation on face of style a long slender rodlike tubercle that bears the second spine, this short, about one-fifth the length of the pale base. Gonapophyses, *g*, broad, the apex a short, more-chitinized beak; a weak lobe on mesal edge. Ædeagus, *a*, large, the apex obtuse.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Sweeping in ferns and undergrowth along margins of small brook."

Limonia (*Limonia*) *claggi* is named in honor of the collector, Mr. Charles F. Clagg, to whom I am very greatly indebted for invaluable crane flies from the high mountains of Mindanao. The species obviously belongs to the *trigonia* group, having Sc

unusually long and with m-cu beyond the fork of M. The latter characters would serve to place the species of the *trigonia* group in the subgenus *Libnotes*, whereas their true affinities seem to lie with *Limonia* s. s.

LIMONIA (LIMONIA) SYNCHÆTA sp. nov. Plate 1, fig. 4; Plate 2, fig. 30.

General coloration black, the præscutum with three reddish brown stripes; halteres infuscated; legs black; wings with a strong brown tinge, sparsely seamed along cord and outer end of cell 1st M_2 with darker brown; stigmal area restricted to a narrow seam at the fork of R_1 ; male hypopygium with the two rostral spines of the ventral dististyle arising basad of a long yellow boomerang-shaped structure, the spines from a common fused base that divides into unequal pale tubercles.

Male.—Length, about 6 to 8 millimeters; wing, 7 to 9.5.

Rostrum and palpi black. Antennæ black throughout; basal flagellar segments subglobular, the outer segments passing into oval; verticils relatively inconspicuous, on basal segments shorter than the segments themselves, on outer segments becoming more elongate. Head black.

Pronotum black. Mesonotal præscutum black, the three usual stripes reddish brown; scutal lobes with centers reddish brown, bordered by blackish; scutellum chiefly pale; postnotal mediotergite darkened on anterior portion, paler behind. Pleura chiefly dark brown, vaguely brightened in places, as on the ventral sternopleurite; dorsopleural region pale. Halteres infuscated, the extreme base of stem brightened. Legs with the coxæ and trochanters obscure yellow; remainder of legs black; claws long and slender, with a single acute basal spine. Wings (Plate 1, fig. 4) with a strong brown tinge, restrictedly patterned at origin of R_s , along cord and outer end of cell 1st M_2 , and as a narrow stigmal seam at the fork of R_1 with darker brown; veins darker brown. Costal fringe of moderate length. Venation: Sc_1 ending about opposite three-fourths the length of R_s , Sc_2 at its tip; R_s nearly square at origin; free tip of Sc_2 opposite or a little before the level of R_2 ; m-cu just before the fork of M.

Abdominal tergites black, the basal sternites black, their bases restrictedly pale; hypopygium chiefly dark. Male hypopygium (Plate 2, fig. 30) with the caudal margin of the tergite, 9t, very gently emarginate, the very low lateral lobes with long coarse setæ. Basistyle, *b*, relatively short and stout, the ventromesal lobe broad, basal in position, at apex with a smaller lobule that bears two long and two short setæ. Ventral dististyle, *vd*,

relatively small and oval, the rostral prolongation a long, pale yellow, boomerang-shaped structure, the usual spines arising from a common flattened base that branches into two unequal tubercles, the outer longer, bearing a somewhat longer spine, the inner tubercle short, its spine a trifle shortened. Dorsal dististyle with the outer margin with microscopic spinulæ. Gonapophyses, *g*, with the mesal-apical lobe relatively slender, smooth, and gently curved.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Among ferns and undergrowth along margins of small brook;" Mount Apo, 7,000 feet, September 11, 1930 (*Clagg*); paratype, male. LUZON, Laguna Province, above Ube, altitude about 1,625 feet, December 22, 1929 (*McGregor*); paratype, male.

Limonia (*Limonia*) *synchæta* is well-distinguished by the peculiar structure of the male hypopygium. The type is smaller than the paratype but is undoubtedly conspecific.

LIMONIA (LIMONIA) PLEIADES sp. nov. Plate 1, fig. 5; Plate 2, fig. 31.

General coloration castaneous; wings with the cephalic half strongly suffused with brown, the posterior half gray; seven circular to oval whitish hyaline droplets in cells of wing, these slightly ringed with darker; male hypopygium with the rostral prolongation remote from the basal spine of the ventral dististyle.

Male.—Length, about 5.5 millimeters; wing, 4.8 to 5.

Female.—Length, about 6 millimeters; wing, 5.5.

Rostrum and palpi small, dark brown. Antennæ dark brown; basal flagellar segments subglobular, becoming oval and then elongate-oval outwardly, the segments on outer face with very long verticils, those on the inner face shorter but still long and conspicuous. Head blackened behind, heavily pruinose with silvery, especially on the front and anterior vertex, the latter wide in both sexes.

Pronotum brownish black. Mesonotum castaneous, nitidous, the pleura more variegated with darker. Halteres dark brown. Legs with the coxæ and trochanters yellow; femora yellow, the tips slightly enlarged and conspicuously blackened, the amount subequal on all legs; fore tibiæ black, the other tibiæ paler, tipped with black; tarsi black; claws long and slender, with an elongate spine at near one-third the length, together with two additional progressively smaller spines at base. Wings (Plate 1, fig. 5) with the cephalic half strongly suffused with brown, the posterior cells paler, more grayish; cord and outer end of

cell 1st M_2 seamed with darker brown, in cases suffusing the stigmal region and adjoining portions of the radial field; axilla weakly darkened; seven circular to oval whitish-hyaline areas, one each in cells R , R_1 , Sc_1 , R_2 , R_3 near outer end, center of 1st M_2 , and near base of 2d M_2 , these droplets narrowly bordered by brown; veins dark brown. Venation: Sc long, Sc_1 ending about opposite four-fifths to five-sixths Rs , Sc_2 at its tip; $m-cu$ at fork of M . The hyaline droplets distort the following veins: $Costa$ and R just beyond the fork of Sc , Rs just before midlength, R_3 just beyond R_2 , R_{4+5} near outer end, second and third sections of M_{1+2} , and outer section of M_3 before midlength.

Basal abdominal tergites black, the caudal portions broadly black; outer tergites black, with metallic green reflections; basal sternites similarly dimidiate yellow and black, the outer segments dull black; hypopygium chiefly yellow, the basistyles darkened apically. Male hypopygium (Plate 2, fig. 31) with the caudal margin of the tergite, $9t$, very shallowly notched. Basistyle, b , long and slender, the ventromesal lobe relatively small. Dorsal dististyle nearly straight, the apex a little expanded, narrowed to an acute point. Ventral dististyle, vd , small, fleshy, the cephalic mesal portion produced into a slender rod that is tipped by a long black spine; mesal face of style at near midlength bearing the rostral prolongation, the latter at near midlength with a slender hairlike spine. Gonapophyses with the mesal-apical lobe slender, the tip acute. $\text{\AA}edeagus$, a , bifurcate at tip. Ovipositor with the genital shield of the tergal valves very large, the valves correspondingly reduced; sternal valves very large.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 4 and 5, 1930, by sweeping (*Clagg*); holotype, male; allotype, female; paratypes, 2 males; Mount Apo, 7,000 to 8,000 feet, September 21, 1930 (*Clagg*); paratypes, 1 male and 1 female.

The specific name of this charming fly is derived from the seven conspicuous droplets on the wing membrane. I can suggest no closely allied form.

LIMONIA (LIMONIA) PRNOTALIS sp. nov. Plate 1, fig. 6.

Head obscure yellow, blackened behind; pronotum orange; mesonotum blue-black, the sides of the præscutum and the dorsopleural region intensely black; knobs of halteres ivory white; fore femora black, the basal fourth pale; tibiæ darkened; wings suffused with brown, the prearcular and costal regions more whitish, without a pale crossband before the cord.

Female.—Length, about 5.5 millimeters; wing, 5.3.

Rostrum and mouth parts very much reduced to nearly lacking. Antennæ with the scape obscure yellow, the flagellum black; basal flagellar segments short, subglobular, their ends truncated, the outer segments more elongate and slender; verticils of basal segments short and inconspicuous, outwardly becoming longer, subequal to or exceeding the segments. Front obscure yellow, the broad vertex more-polished black.

Pronotum fiery orange. Mesonotal præscutum polished blue-black, more intensely blackened on the sides; humeral region obscure yellow; median region of præscutum and scutum brightened at suture; remainder of notum blue-black. Pleura with the dorsopleural region intense black; sternopleurite paler, more brownish; pleurotergite black. Halteres brown, the knobs ivory white. Legs with the coxæ and trochanters pale yellow; fore femora black, only the basal fourth pale; middle and posterior femora yellow with about the distal seventh blackened; fore tibiæ black, the other tibiæ somewhat paler, tipped with black; tarsi brown; claws with a subobtusate basal tooth that bears a long pale seta. Wings (Plate 1, fig. 6) with a uniform brown suffusion, the prearcular and costal regions more whitish, the latter involving the base of cell R; stigma small, ill-delimited; no hyaline crossband before cord, as in *citrofocalis*; veins dark brown. Venation: Sc_1 ending at near midlength of Rs, Sc_2 at its tip; free tip of Sc_2 pale, subequal to the section of R_1 beyond; R_2 pale, without macrotrichia; basal section of R_{4+5} strongly arcuated; cell 1st M_2 closed; m-cu at fork of M, long, sinuous, exceeding the distal section of Cu_1 ; anal veins parallel at base.

Abdominal tergites black, the subterminal segment abruptly light yellow; sternites conspicuously pale medially, the lateral portions darkened; genital segment black. Ovipositor with the tergal valves slender, strongly upcurved.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2, 1930 (*Clagg*); holotype, female. "Among ferns and on mossy trees;" Mount Apo, 6,000 to 7,000 feet, September 1 to 11, 1930 (*Clagg*); paratypes, 4 males and females.

Limonia (Limonia) pronotalis is most closely allied to *L. (L.) citrofocalis* (Edwards), of Borneo, differing most evidently in the uniformly infuscated wings, without a hyaline crossband before the cord, together with the details of coloration of body and fore femora.

LIMONIA (LIMONIA) CYNOTIS sp. nov. Plate 1, fig. 7; Plate 2, fig. 32.

General coloration dark brown; antennæ black throughout; knobs of halteres and the legs blackened; wings with a strong blackish suffusion; male hypopygium with the dististyle single, shaped more or less like a dog's ear, the mesal face densely hairy.

Male.—Length, about 5 millimeters; wing, 5.2.

Female.—Length, about 5.5 millimeters; wing, 5.8.

Rostrum dark brown; palpi black. Antennæ black throughout; basal flagellar segments globular, the outer ones more oval, with short verticils. Head black.

Pronotum dark brown. Mesonotum uniformly dark brown, the surface subnitidous. Pleura brown, a little paler than the notum; dorsopleural membrane blackened. Halteres dusky, the base of stem restrictedly brightened, the knobs blackened. Legs with the coxæ pale brown; trochanters yellow; remainder of legs black. Wings (Plate 1, fig. 7) with a strong blackish suffusion; stigma lacking; veins darker than the ground color. Venation: Sc_1 ending just before midlength of Rs , Sc_2 at its tip; Rs long; free tip of Sc_2 perpendicular, some distance before R_2 ; $m-cu$ close to fork of M ; vein $2d$ A relatively long.

Abdomen, including the hypopygium, black. Male hypopygium (Plate 2, fig. 32) with the tergite, $9t$, large. Basistyle, b , with the ventromesal lobe relatively small. A single dististyle, d , shaped more or less like a dog's ear, broad at base, narrowed outwardly to a point, the mesal face densely set with erect black setæ; outer margin of style near base with a small hemispherical tubercle that bears two large setæ. Gonapophyses, g , with the mesal-apical lobes appearing as elongate dusky blades. $\mathcal{A}$ edeagus, a , large, bifid at apex, the surface with abundant erect microscopic setulæ.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 2 and 3, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 2 males and 2 females. "Among ferns and undergrowth along margins of brook."

Limonia (*Limonia*) *cynotis* is well distinguished by the combination of characters outlined above, more especially the uniformly blackened wings and peculiar structure of the male hypopygium.

LIMONIA (LIMONIA) PROLIXICORNIS sp. nov. Plate 1, fig. 8; Plate 2, fig. 33.

General coloration reddish brown; antennæ (male) elongate, nearly one-half the length of the body; halteres infuscated; wings tinged with brown; Sc_1 ending opposite or beyond mid-

length of R_s , Sc_2 a short distance from its tip; cell M_2 open by atrophy of m ; male hypopygium without dorsal dististyle; ventral dististyle subglobular, the rostral prolongation long and slender, without spines.

Male.—Length, about 3.3 to 3.4 millimeters; wing, 4.2; antennæ, about 1.5.

Female.—Length, about 4 millimeters; wing, 4.

Rostrum and palpi black. Antennæ black throughout, in male very elongate for a member of this genus, if bent backward extending about to one-third the length of the abdomen; flagellar segments long-oval to fusiform, the apical necks glabrous, the remainder of the segment with abundant erect setæ that are much shorter than the segments; no outstanding verticils. In female, antennæ much shorter, the segments oval to long-oval, with the verticils more evident. Head dark brown.

Mesonotum reddish brown, without markings. Pleura brownish testaceous, somewhat paler ventrally. Halteres infuscated, the extreme base of stem brighter. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs brownish black; claws usually small, nearly straight, each with a group of slender spines at base. Wings (Plate 1, fig. 8) tinged with brown, the oval stigma slightly darker brown; veins dark brown. Venation: Sc_1 ending opposite or beyond midlength of R_s , Sc_2 slightly removed from its tip, Sc_1 alone being subequal or longer than R_2 ; cell M_2 open by the atrophy of m ; cell M_3 relatively deep; vein 2d A at origin converging rather strongly toward vein 1st A.

Abdominal tergites and hypopygium dark brown; basal sternites yellow, the outer segments passing into dark brown. Male hypopygium (Plate 2, fig. 33) with the tergite, 9*t*, produced into long slender lateral lobes, their apices glabrous. Basistyle, *b*, relatively stout, the ventromesal lobe low and obtuse; mesal face of style with a dense area of long coarse setæ. Ventral dististyle, *d*, subglobular, nearly as large as the basistyle, the rostral prolongation very long and slender, slightly expanded at apex but unprovided with rostral spines. Dorsal dististyle lacking. Gonapophyses, *g*, with the mesal-apical lobe recurved at apex, the margin toothed. Ædeagus, *a*, divided at apex into four lobes.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 2 to 4, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 7 males and females. "Among ferns and on mossy trees, everything very damp."

Limonia (*Limonia*) *prolixicornis* is apparently closely allied to *L. (L.) pacata* Alexander (Luzon), differing in the details of venation, as the longer Sc and Sc₁, and deeper cell M₃. Unfortunately, the male of *pacata* is still unknown, and the nature of the antennæ and the male hypopygium cannot be stated.

LIMONIA (LIMONIA) PILOSICAUDATA sp. nov. Plate 1, fig. 9; Plate 2, figs. 34, 35.

General coloration brownish yellow, the præscutum darkened medially behind; femora brownish yellow, more yellowish at tips, this area inclosing a black ring; wings tinged with brown, with a darker brown seamed and spotted pattern; abdominal tergites bicolorous; male hypopygium large and complicated in structure; tergite tumid, with abundant long yellow setæ; ventral dististyle oval, produced at apex into a very long hairy lobe; rostral prolongation very small, at base with a small tubercle that bears two long setoid spines.

Male.—Length, about 8 to 9 millimeters; wing, 9 to 9.5.

Female.—Length, about 10 millimeters; wing, 10 to 11.

Rostrum and palpi black, the former produced, nearly as long as the remainder of head. Antennæ black throughout; flagellar segments subcylindrical, becoming more elongate outwardly, the verticils barely exceeding the segments; terminal segment elongate, about one-half longer than the penultimate. Head dark gray; anterior vertex reduced to a linear strip.

Pronotum brown. Mesonotal præscutum brownish yellow, the median region behind weakly darkened, the stripes otherwise lacking; scutal lobes conspicuously infuscated, the median region pale; scutellum pale basally, margined with darker; postnotal mediotergite dark brown, paler laterally. Pleura generally brownish yellow, the dorsopleural region infuscated. Halteres yellow, the knobs blackened. Legs with the coxæ brownish yellow; trochanters yellow; femora brownish yellow, with a conspicuous black subterminal ring preceded and followed by narrow clearer yellow annuli; tibiæ brown; tarsi passing to darker brown; claws relatively small, with an acute spine and a more-basal seta on proximal third. Wings (Plate 1, fig. 9) tinged with brown, cells C, Sc, and a conspicuous seam along the cubital veins darker brown; stigma small, oval, dark brown; narrow brown seams at origin of Rs, along cord, and on outer end of cell 1st M₂; veins dark brown, paler brown in the costal region. Venation: Sc₁ ending shortly beyond the fork of Rs, Sc₂ near its tip; Rs long, arcuated to weakly angulated at origin; anterior branch of Rs forming a regular curve; cell 1st M₂ long, m-cu close to fork of M.

Abdominal tergites bicolorous, their bases darkened, the apices yellow, the amount of the latter decreasing on the outer segments; sternites more uniformly yellow; hypopygium generally dark brown. Male hypopygium (Plate 2, fig. 34) very large and complicated in structure. Ninth tergite (Plate 2, fig. 35) with the lobes tumid, separated on caudal margin by a small notch, the lobes with very abundant long erect yellow setæ, much longer than the tergite itself. Basistyle, *b*, relatively small, the ventromesal lobe very long, bearing a smaller lateral lobule on basal half, the apex of the lobe conspicuously setiferous. Ventral dististyle, *vd*, an oval structure that is greatly produced at apex into a long-cylindrical hairy lobe; on dorsal face of style a blackened short-hairy lobe, in the notch of which lies the long sinuous dorsal dististyle (not figured); the usual rostral prolongation is a small slender lobe, at base with a small tubercle bearing two very elongate setoid spines. Gonapophyses, *g*, with the mesal-apical lobe a blackened hook. Ovipositor with the tergal valves long and slender, gently upcurved; sternal valves long and straight.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 2 males. "Among ferns and on mossy trees; sweeping in ferns and undergrowth along margins of small brook;" Mount Apo, 6,500 to 8,000 feet, September 10 to 21, 1930 (*Clagg*); paratypes, 8 of both sexes.

Limonia (*Limonia*) *pilosicaudata* might be construed as falling within the limits of the subgenus *Libnotes* but shows certain characters of the typical subgenus wherein I am retaining it. The very peculiar structure of the male hypopygium is distinctive.

LIMONIA (LIMONIA) DAVAOENSIS sp. nov. Plate 1, fig. 10; Plate 3, fig. 36.

General coloration obscure yellow, the præscutum with three confluent brown stripes; antennæ black throughout; a narrow dark brown pleural stripe; knobs of halteres infuscated; wings with a faint brown tinge, the circular stigma darker; male hypopygium with a slender lobe on basistyle, in addition to the long ventromesal lobe; dorsal dististyle pale, straight, hairy; ventral dististyle without rostral spines; gonapophyses with the margin microscopically serrulate.

Male.—Length, about 4.6 to 5 millimeters; wing, 5.2 to 5.8.

Female.—Length, about 5.5 millimeters; wing, 6.

Rostrum and palpi black. Antennæ black throughout; segments oval, with very short apical necks; outer segments more

elongate, the terminal one pointed; verticils short. Head dark brown; anterior vertex (male) reduced to a narrow strip.

Pronotum black, the anterior lateral pretergites yellow. Mesonotal præscutum obscure yellow, the central portion covered by three confluent dark brown stripes, the lateral stripes continued caudad onto the scutal lobes; median area of scutum pale; posterior sclerites of mesonotum infuscated. Pleura yellow, with a distinct dark brown longitudinal stripe that extends from the pronotum to the abdomen, passing beneath the halteres. Halteres infuscated, the extreme base of stem yellow. Legs with the coxæ and trochanters pale yellow; femora brownish yellow, brighter at base, passing into brown at tip; tibiæ and tarsi dark brown; claws relatively long and slender, with a single acute spine near base. Wings (Plate 1, fig. 10) with a faint brown tinge, the prearcular and costal regions a trifle more yellow; wing tip slightly darkened; stigma circular, pale brown; veins dark brown. Venation: Sc_1 ending about opposite two-thirds the length of the arcuated Rs , Sc_2 at its tip; free tip of Sc_2 and R_2 in transverse alignment; m-cu close to the fork of M ; vein 2d A at base converging slightly toward 1st A.

Abdominal tergites dark brown, the extreme caudal margins of the segments ringed with reddish brown; sternites more uniformly darkened; hypopygium dark brown. Male hypopygium (Plate 3, fig. 36) with the tergite, 9*t*, long, gradually narrowed outwardly, the narrow apex subtruncate to very weakly concave; a marginal series of about five coarse setæ on either side. Basistyle, *b*, with the ventromesal lobe basal in position, very long, narrowed outwardly, provided with long coarse setæ, with a small basal lobule in axil; on mesal face of style but more apical in position a slender dark lobe that terminates in about six stout yellow setæ. Dorsal dististyle a pale straight rod, narrowed to a point, the tip acute. Ventral dististyle, *vd*, relatively small, of unusual form, with two dusky setiferous lobes at base; rostral blade stout, without evidently developed spines. Gonapophyses, *g*, with the outer margin of the mesal-apical lobe with abundant microscopic sawlike teeth or ridges. Ovipositor with the valves long and slender.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 3 and 4, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 3 males. "Among ferns and undergrowth along margins of small brook;" Mount Apo, 7,000 to 8,000 feet, September 30, 1930 (*Clagg*); paratype, male.

Limonia (Limonia) davaoensis is very distinct from other regional species in the peculiar structure of the male hypopygium.

LIMONIA (LIMONIA) CALIANENSIS sp. nov. Plate 1, fig. 11; Plate 3, fig. 37.

General coloration brown; antennæ black throughout; mesonotal præscutum brown, with three yellow stripes; pleura yellow, with a broad black longitudinal stripe; wings pale brown, unmarked; abdomen black, the basal sternites yellow; male hypopygium with the basistyle long and slender, the ventromesal lobe extensive, appressed to the face of the style; ventral dististyle relatively small, the two spines of the rostral prolongation long, appressed to the face of the prolongation, blunt or weakly notched at tips.

Male.—Length, about 5.2 millimeters; wing, 6.2.

Rostrum small, brownish yellow; palpi black. Antennæ black throughout; basal segments short-oval, with short glabrous apical necks; outer segments more elongate-oval, terminal segment about one-third longer than the penultimate; flagellar verticils long and conspicuous, the longest on the outer segments fully twice as long as the segments. Head rich brown; anterior vertex wider than the first scapal segment.

Pronotum dark in front, paler behind. Mesonotal præscutum brown, the three usual stripes yellow, the median one broad, the laterals narrow, crossing the suture onto the lateral portions of the scutal lobes; posterior sclerites of mesonotum chiefly darkened, the median area of the scutum and scutellum somewhat more testaceous. Pleura pale yellow, with a broad black longitudinal stripe extending from the pronotum to the abdomen, passing beneath the root of the halteres, leaving a pale area dorsad of this beneath the wing root and on the dorsal pleurotergite; dorsopleural region infuscated. Halteres brownish black. Legs with the coxæ and trochanters yellow; remainder of legs light brown, only the terminal tarsal segments darker; claws long and slender, with a single long basal spine. Wings (Plate 1, fig. 11) with a pale brown tinge, without markings; veins darker brown. Costal fringe of moderate length. Venation: Sc_1 ending at midlength of R_s , Sc_2 at its tip; free tip of Sc_2 and R_2 in transverse alignment; m-cu at fork of M; vein 2d A at origin converging very insensibly toward 1st A.

Abdominal tergites brownish black; basal sternites yellow, beyond the second passing into black; hypopygium dark brown.

Male hypopygium (Plate 3, fig. 37) with the ninth tergite, 9t, transverse, the caudal margin weakly concave, with about four submarginal setæ on either side. Basistyle, *b*, long and slender, the ventromesal lobe large, appressed to the mesal face of the style. Ventral dististyle, *vd*, much smaller than the basistyle, oval, the rostral prolongation conspicuous, chitinized; rostral spines two, basal in position, directed outward along the face of the prolongation; spines elongate, their tips blunt or weakly notched. Dorsal dististyle a gently curved chitinized rod, narrowed to the acute tip. Gonapophyses, *g*, with the mesal-apical lobe long and nearly straight, the margins smooth.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 3, 1930 (*Clagg*); holotype, male; Mount Apo, 8,000 feet, September 15, 1930 (*Clagg*); paratype, male.

Limonia (*Limonia*) *calianensis* is superficially like *L. (L.) ligayai* Alexander (Luzon) and other similar species but is amply distinct in the structure of the male hypopygium, in conjunction with other characters as outlined.

LIMONIA (LIBNOTES) BELLULA sp. nov. Plate 1, fig. 12; Plate 3, fig. 38.

General coloration pale yellow; mesonotal præscutum with an Λ -shaped black area that extends across the suture onto the scutal lobes; antennal flagellum pale; knobs of halteres and the femoral tips blackened; wings whitish subhyaline, with a heavy brown pattern, including a large area at arculus and a narrow lunate line before the wing tip; origin of R_s square, of R_{2+3} subangular; male hypopygium with the ventral dististyle large and fleshy, the rostral prolongation very short, with two unequal spines, the outer one widened into a pale flange.

Male.—Length, about 5.5 to 6 millimeters; wing, 5.8 to 6.5.

Female.—Length, about 6.5 millimeters; wing, 6.2.

Rostrum and palpi black. Antennæ with the scapal segments black, the flagellum much paler, brownish yellow; flagellar segments oval, becoming more slender and elongate outwardly; a unilateral series of very long verticils. Head gray; anterior vertex reduced to a linear strip.

Pronotum black, yellow laterally. Mesonotum yellow, the præscutum with Λ -shaped black area, consisting of the confluent median and lateral stripes, the posterior half of the former being replaced by yellow; lateral stripes crossing the suture onto the scutal lobes; scutellum pale yellow; postnotal mediotergite weakly infuscated. Pleura yellow. Halteres yellow, the knobs of the halteres black. Legs with the coxæ and trochanters

pale yellow; femora yellow, the tips narrowly but conspicuously blackened, the amount subequal on all legs; remainder of legs pale yellow; claws of moderate size, with a single developed spine. Wings (Plate 1, fig. 12) whitish subhyaline, the prearcular and costal regions more suffused with yellow; a heavy brown pattern, distributed as follows: At arculus, extending from costa to vein 1st A; origin of Rs, completely traversing cell R; stigma, extended caudad to vein R_{4+5} ; a narrow lunate darkening before wing tip, the concave side of the area being directed outward, extending from costa across the radial and medial fields to vein M_3 ; a narrow dark margin from cell R_2 into cell Cu; cord and outer end of cell 1st M_2 with narrow brown seams; an oval spot near end of vein 1st A; axilla narrowly darkened; veins yellow, brown where traversing the darkened areas; veins C, Sc, and R brighter yellow. Costal fringe relatively long and conspicuous; macrotrichia of veins beyond cord long and conspicuous. Venation: Sc ending just beyond fork of Rs, Sc_2 far from its tip; Rs strongly angulated to square at origin; R_{2+3} subangular at origin; m-cu at from one-third to one-half the length of cell 1st M_2 ; anal veins evenly diverging.

Abdominal tergites yellow, the caudal margin very broadly brownish black; sternites more uniformly pale; hypopygium yellow, the basistyles conspicuously darkened. Male hypopygium (Plate 3, fig. 38) with the tergite, 9t, unusually long, the caudal lobes very conspicuous, provided with long erect setæ. Basistyle, *b*, relatively small, the ventromesal lobe basal in position, small. Ventral dististyle, *vd*, very large and fleshy, the rostral prolongation small, with two very unequal spines, the outer unusually wide, its outer margin a pale flange, the inner spine small and delicate. Gonapophyses, *g*, with the mesal-apical angle microscopically serrulate along margin. Ædeagus slightly bifid at apex.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 to 5,800 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 1 male and 1 female. "Among ferns and on mossy trees; among ferns and undergrowth along margins of a small brook;" Mount Apo, 7,000 feet, September 15, 1930 (*Clagg*); paratype, female. LUZON, Laguna Province, above Ube, February 3 to 9, 1930 (*Rivera*); paratypes, 7 males and females.

Limonia (*Libnotes*) *bellula* approaches very closely the characters of the subgenus *Goniodineura* van der Wulp. By Ed-

wards's key to the species of *Libnotes*² the present species runs to couplet 58, disagreeing with both included species in all details of coloration. If the arcuation of the base of R_{2+3} is considered as being an angulation, the present species runs to couplet 54, *nigriceps* (van der Wulp), type of the subgenus *Goniodineura*.

HELIUS (HELIUS) TRIANGULIFERUS sp. nov. Plate 1, fig. 13.

General coloration reddish brown; rostrum and legs black; wings gray; anterior branch of Rs short, directed cephalad and fused for a short distance back from the margin with R_1 , forming a small closed triangular cell that is nearly filled by a gray stigmal area.

Male.—Length, about 3 millimeters; wing, 3.2.

Female.—Length, about 3.7 to 4 millimeters; wing, 3.8 to 4.2.

Rostrum about as long as the remainder of head, black; palpi black. Antennæ black throughout. Head black.

Mesonotum and pleura light reddish yellow, unmarked, darker in the paratype. Halteres infuscated. Legs with the coxæ and trochanters brownish yellow; remainder of legs black, the femoral bases restrictedly pale; terminal tarsal segments paling to yellowish brown. Wings (Plate 1, fig. 13) gray, the stigma slightly darker gray, almost filling the triangular cell R_1 ; a narrow apical clouding in cell R_3 ; veins dark brown. Costal fringe (male) relatively long and conspicuous. Venation: Sc_1 ending just beyond origin of Rs, Sc_2 shortly before this origin; anterior branch of Rs (R_{2+3}) very short, fused for a short distance back from the margin with R_1 , forming a small closed triangular cell; cell R_3 at margin correspondingly extensive; inner end of cell 1st M_2 arcuated; m-cu at or close to fork of M.

Abdomen dark brown. Ovipositor with the valves very long and slender, blackened.

LUZON, Laguna Province, above Ube, February 11, 1930 (*Rivera*); holotype, male; allotype, female. MINDANAO, Davao district, Calian, La Lun Mountains, at trap lantern, altitude 5,500 feet, July 4, 1930 (*Clagg*); paratype, female; Mount Apo, 6,000 feet, September 23, 1930 (*Clagg*); paratype, female.

The peculiar venation suffices to distinguish the present species. The Mindanao paratypes are slightly larger and darker but seem unquestionably to belong here.

² Journ. Fed. Malay States Mus. 14 (1928) 74-80.

HEXATOMINI

Genus EPIPHRAGMA Osten Sacken

Subgenus POLYPHRAGMA novum

Characters as in *Epiphragma* s. s., differing as follows: Basal segments of antennal flagellum united into a fusion segment; supernumerary crossveins and spurs in cell C, additional to the one normally present; a weak supernumerary crossvein in cell Cu, this rarely lacking.

Type of the subgenus, *Epiphragma bakeri* Alexander (Oriental Region).

Besides the subgenotype, the following species belong here: *Epiphragma cinereinota* Alexander, *crenulata* Alexander, *flavosternata* Alexander, *fulvinota* sp. nov., *fuscinota* sp. nov., *fuscosternata* Alexander, *ochrinota* Alexander, *subcrenulata* Alexander, and *triarmata* sp. nov. All the known species of the subgenus are from the Philippines and Borneo.

EPIPHRAGMA (POLYPHRAGMA) FUSCINOTA sp. nov. Plate 1, fig. 14; Plate 3, fig. 39.

General coloration of mesonotum brown; femora brown; in cases with the tips abruptly pale yellow; tarsi yellow; wings gray, the ground color almost obliterated by a heavy brown pattern; cell 2d A uniformly darkened; male hypopygium with the interbasal process expanded at apex into a simple smooth blade.

Male.—Length, about 7.5 to 8 millimeters; wing, 8.5 to 9.

Rostrum and palpi black. Antennæ black, the fusion segment only slightly brightened. Head with the vertex obscure fulvous, with a median dark brown vitta and a posterior orbital darkening.

Posterior pronotum obscure yellow. Mesonotum generally brown, the humeral and lateral portions of the præscutum somewhat darker brown. Pleura somewhat darker brown than the notum, the ventral sternopleurite paling to yellowish. Halteres elongate, obscure yellow, the knobs darkened. Legs with the fore coxæ obscure yellow, the other coxæ somewhat darker; trochanters obscure yellow; femora infuscated, the bases brightened, the tips narrowly and abruptly yellow; tibiæ brown, the tips paling to obscure brownish yellow; tarsi yellowish. The Luzon paratype lacks the yellow femoral tips. Wings (Plate 1, fig. 14) gray, the costal region more yellowish gray, the ground

color chiefly obliterated by a very heavy brown pattern, darker brown along the costal margin; cell 2d A uniformly darkened. Venation: Supernumerary crossveins and spurs in cell C relatively few in number; Rs angulated to short-spurred at origin; m-cu variable in position, in the holotype figured being at mid-length of cell 1st M_2 , in the paratype less than its own length beyond the fork or M.

Abdominal tergites dark brown; sternites weakly bicolorous, obscure brownish yellow, the incisures and, more especially, the bases of the segments infuscated; hypopygium chiefly dark. Male hypopygium (Plate 3, fig. 39) with the outer dististyle, *od*, a chitinized rod, the tip curved into an acute spine, before apex with a small ventral tooth. Inner dististyle, *id*, expanded at apex into a head, the outer margin with a subspinous crest. Interbasal process, *i*, elongate, at apex expanded into a smooth, flattened obtuse blade.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Sweeping ferns and undergrowth along margins of small brook." LUZON, Laguna Province, above Ube, February 3 to 9, 1930 (*Rivera*); paratype, male.

The paratype is slightly smaller and differs in details of leg coloration and wing venation from the type. However, the structure of the male hypopygium is the same, and I must regard the two specimens as being conspecific.

EPIPHRAGMA (POLYPHRAGMA) FULVINOTA sp. nov. Plate 1, fig. 15; Plate 2, fig. 40.

Mesonotum dull fulvous, the pleura brownish black; legs yellow, the femora with a broad dark brown subterminal ring; wings yellowish brown, the costal region brighter yellow; a heavy brown pattern, the areas not bordered by paler; male hypopygium with the base of the outer dististyle elevated into abundant points to produce a crownlike appearance; interbasal process a simple flattened blade, the apex a curved beak.

Male.—Length, about 6.5 millimeters; wing, 7.5.

Rostrum and palpi brownish black. Antennæ with the scape dull ochereous, the fusion segment fulvous; remainder of antennæ dark brown. Head grayish, more infuscated on posterior orbits.

Mesonotum dull fulvous, the scutellum and postnotum a little darker. Pleura and pleurotergite conspicuously brownish black. Halteres yellow, the knobs infuscated. Legs with the coxæ brownish yellow, brightened apically; trochanters yellow; femora yellow, with a broad dark brown subterminal ring, the ex-

treme apex bright yellow; tibiæ and tarsi light yellow. Wings (Plate 1, fig. 15) tinged with yellowish brown, the prearcular and costal regions clear yellow; a heavy brown pattern, the areas not bordered by paler; a series of alternating brown and yellow areas on costa to wing tip; the most conspicuous of the dark clouds are marginal at ends of all longitudinal veins, at origin of Rs and on the supernumerary crossvein in cell Cu; cord, outer end of cell 1st M_2 and fork of M_{1+2} conspicuously seamed with brown; veins dark brown, alternately yellow and brown in the costal region. Venation: Supernumerary crossveins and spurs in cell C relatively few in number, there being only one or two beyond the origin of Rs; m-cu at about two-thirds its length beyond the fork of M.

Abdominal tergites yellowish brown, margined laterally with darker brown; sternites clearer yellow; hypopygium brown. Male hypopygium (Plate 3, fig. 40) with the caudal margin of the tergite, 9t, produced into two slender glabrous spinous lobes that are separated by a broad U-shaped notch. Outer dististyle, *od*, broadest on basal half, the outer margin with abundant spinous points and tubercles to produce a crownlike appearance. Interbasal process, *i*, a flattened blade, relatively narrow, the apex a simple strongly curved beak, as figured.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 5, 1930, by sweeping (*Clagg*); holotype, male; Mount Apo, 7,000 to 8,000 feet, September 1 to 20, 1930 (*Clagg*); several paratypes, both sexes.

Epiphragma (*Polyphragma*) *fulvinota* bears a marked superficial resemblance to *E. (P.) ochrinota* Alexander (Luzon), but differs very conspicuously in the structure of the male hypopygium.

EPIPHRAGMA (POLYPHRAGMA) TRIARMATA sp. nov. Plate 1, fig. 16; Plate 3, fig. 41.

Male.—Length, about 7.5 to 8 millimeters; wing, 8.2 to 9.

Female.—Length, about 10 millimeters; wing, 9.

Generally similar in appearance to *E. (P.) ochrinota* Alexander, differing especially in the larger size and structure of the male hypopygium.

Antennal scape pale brown to brown, the fusion segment obscure fulvous. Head dull brown.

Mesonotum uniformly dull fulvous, the pleura abruptly dark brown; ventral sternopleurite paler. Halteres elongate, yellow, the knobs infuscated. Legs yellow, the darkened femoral ring

pale brown. Wings (Plate 1, fig. 16) grayish brown, the prearcular and costal regions light yellow; a heavy brown pattern that is conspicuously margined with pale yellow. Venation: Relatively numerous crossveins and spurs in cell C, including two or three beyond the origin of Rs.

Abdominal tergites brown, the basal sternites brighter, more yellowish, darkened laterally; hypopygium dark. Male hypopygium (Plate 3, fig. 41) with the ninth tergite, 9*t*, bearing two broad lobes that are separated by a V-shaped notch. Outer dististyle, *od*, curved to a simple chitinized hook. Inner dististyle angulated at midlength. Interbasal process, *i*, complicated in structure, at apex bearing three lobes, including a flattened paddlelike arm and a glabrous branch that terminates in an acute spine and a lower obtuse lobe.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2 to 5, 1930 (*Clagg*); holotype, male; allotype, female; paratype, male. "Sweeping among ferns and on mossy trees."

ADELPHOMYIA CARBONICOLOR sp. nov. Plate 1, fig. 17.

General coloration of thorax shiny coal-black; wings with a grayish tinge, sparsely patterned with brown; Sc_1 long; R_2 at fork of R_{3+4} .

Male.—Length, about 4.5 millimeters; wing, 4.7.

Rostrum and palpi black. Antennæ black throughout. Head dull blackish gray.

Pronotum, mesonotum, and pleura shiny coal-black. Halteres yellow, the knobs dark brown. Legs with the fore coxæ pale brown, the remaining coxæ yellow; trochanters yellow; remainder of legs broken. Wings (Plate 1, fig. 17) with a grayish tinge, the costal third a little more cream-colored; a sparse brown pattern, including the stigma, a paler cloud at origin of Rs, a narrow seam on anterior cord, and weak gray clouds on posterior cord, outer end of cell 1st M_2 , Sc_2 , and as an arcular suffusion; veins pale, darker in the infuscated areas. Macrotrichia of cells relatively few. Venation: Sc_2 some distance from the tip of Sc_1 ; Rs angulated and weakly spurred at origin; R_2 at fork of R_{3+4} ; cell M_1 small; m-cu from one-third to one-half its length beyond the fork of M.

Abdominal tergites black; sternites brownish black, the caudal margins of the intermediate segments a little paler; hypopygium dark.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Among ferns and undergrowth along margins of small brook."

Adelphomyia carbonicolor is most closely related to *A. luzonensis* Alexander (Luzon), differing most evidently in the polished black thorax, and details of wing pattern and venation. The wings of the present species are noticeably wider, but this may well be a sexual character.

LIMNOPHILA (DICRANOPHRAGMA) RETRACTA sp. nov. Plate 1, fig. 18.

General coloration brownish gray, the thorax immaculate; antennal scape black, the basal flagellar segments pale brown; legs and halteres yellow; wings whitish, with a restricted brown pattern, the six dark costal areas narrow; supernumerary crossvein in cell R_3 more than twice its length from tip of vein R_3 .

Female.—Length, about 5.5 millimeters; wing, 4.8.

Rostrum and palpi black. Antennæ with the scapal segments black; basal flagellar segments pale brown, the outer segments passing into darker brown. Head dark, sparsely pruinose.

Mesonotum brownish gray, without markings, the posterior sclerites more blackish, sparsely pollinose. Pleura dark brown, sparsely pruinose. Halteres obscure yellow. Legs with the fore coxæ dark brown, the other coxæ paler; trochanters obscure yellow; remainder of legs yellow, the terminal tarsal segments darkened. Wings (Plate 1, fig. 18) whitish, the prearcular and costal regions very slightly more yellow; a relatively sparse spotted brown pattern, including six relatively narrow costal blotches, the second at origin of R_s , the third at fork of Sc , the fourth at fork of R_1 , the two latter connected posteriorly to form a V-shaped area along the anterior cord, leaving a small whitish area in cell Sc_1 ; relatively large brown marginal spots at ends of all the longitudinal veins, these becoming progressively larger back from the wing tip; remainder of wing disk with small, chiefly circular or irregular areas in all cells, these not forming conspicuous transverse lines; veins pale, darker in the clouded areas. Venation: Sc_1 ending opposite the fork of R_{2+3+4} , Sc_2 about opposite midlength of the latter vein; supernumerary crossvein in cell R_3 more than twice its own length back from tip; cell M_1 about two-thirds its petiole; m-cu less than its own length beyond fork of M .

Abdomen dark brown; valves of ovipositor long and slender, the long tergal valves brown, paling to horn color at tips; sternal valves entirely dark, straight.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2, 1930 (*Clagg*); holotype, female.

Limnophila (*Dicranophragma*) *retracta* is most closely related to *L. (D.) remota* (de Meijere), differing most evidently in the unmarked mesonotal præscutum and the more sparsely patterned wings.

LIMNOPHILA (DICRANOPHRAGMA) RADIALIS sp. nov.

General coloration of mesonotal præscutum light buffy gray, immaculate; wings whitish, the costal region light yellow; a very abundant brown pattern that is heavier and darker in the radial field; wing tip narrowly clear yellow; supernumerary crossvein in cell R_3 far from tip of vein R_3 .

Female.—Length, about 6 millimeters; wing, 5.5.

Rostrum and palpi black. Antennæ with the scapal segments black, the flagellum chiefly dark brown. Head dark gray.

Mesonotal præscutum light buffy gray, without markings; pseudosutural foveæ pale; posterior sclerites of mesonotum darker gray. Pleura dark, sparsely pruinose. Halteres light dusky, the knobs weakly infuscated. Legs with the coxæ yellow, the fore and middle coxæ a little darker and weakly pruinose; remainder of legs yellow, the tips of the tarsi weakly darkened. Wings with the ground color whitish, the costal region light yellow; a very abundant dotted and transversely streaked brown pattern that becomes conspicuously darker and heavier in the radial field, where the ground color is reduced to tiny spots and dots; the marginal areas at ends of medial and cubical veins ring-like, with pale centers; the areas in the cells are dots and spots that tend to flow together; in cells M, Cu, 1st A, and 2d A the areas are more elongate and transverse; dark areas in costal field reduced in number; wing tip in radial and medial fields narrowly clear light yellow; veins pale, somewhat darker in the infuscated areas. Venation; Supernumerary crossvein in cell R_3 about two and one-half times its length from tip of vein R_3 , the second section of this vein being about one-third longer than the basal section.

Abdomen dark brown.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 4, 1930, at trap lantern (*Clagg*); holotype, female; paratype, female.

Limnophila (*Dicranophragma*) *radialis* is allied to *L. (D.) retracta* sp. nov., but is sufficiently well distinguished by the characters outlined above.

ERIOPTERINI

GONOMYIA (LIPOPHLEPS) PTILOSTENELLA sp. nov. Plate 1, fig. 19; Plate 3, fig. 42.

General coloration black, sparsely variegated with pale, including a longitudinal silvery white stripe on pleura; antennæ, halteres, and legs black; wings with a dusky tinge; Sc_1 ending opposite the origin of R_s , Sc_2 far from its tip; cell 2d M_2 small; m-cu far before the fork of M .

Male.—Length, about 2.5 millimeters; wing, 3.2.

Female.—Length, about 3 to 3.8 millimeters; wing, 3.5.

Rostrum very short, black, margined in front with paler; palpi black. Antennæ black throughout; flagellar segments oval; segments with a dense erect white pubescence and slightly longer, but inconspicuous verticils, the latter not greatly elongated in the male, as usual in *Lipophleps*. Head black, sparsely pruinose, the narrow orbits and anterior vertex pale.

Pronotum black; anterior lateral pretergites conspicuously light yellow, the narrow posterior lateral pretergites white. Mesonotal præscutum black, subnitidous; humeral triangles small, yellow; pseudosutural foveæ large, polished black; scutum black, with a small obscure yellow spot on either side of the midline behind the suture; scutellum broad, black, pruinose, postnotal mediotergite black, the cephalic portion with a broad pale yellow V-shaped area. Pleura black, pruinose, with a broad silvery white longitudinal stripe on the dorsal sternopleurite, becoming broader behind; posterior dorsal pleurites whitish. Halteres black. Legs black. Wings (Plate 1, fig. 19) with a dusky tinge; veins brownish black. Venation: Prearcular region notably developed in both sexes; Sc_1 ending opposite the origin of R_s , Sc_2 far from its tip, at near mid-distance between arculus and origin of R_s ; cell 2d M_2 very small, from two-fifths to one-third its petiole; m-cu about its own length before the fork of M .

Abdomen black, the pleural membrane yellow; hypopygium brownish yellow. Male hypopygium (Plate 3, fig. 42) with the ninth tergite, 9*t*, large, the caudal margin with a conspicuous V-shaped median notch, the broad lobes thus formed truncate or nearly so. Basistyle, *b*, produced caudad into a stout lateral and an equally long but more slender mesal lobe, both conspicuously setiferous. Two dististyles, *d*, borne in the notch of the

basistyle, the outer a pale glabrous rod that is sinuously narrowed to an acute point; inner style subequal or longer, pale, divided at tip into two broad pale blades; at midlength of the style with numerous delicate erect setulæ. Ovipositor with the tergal valves black, the hairy sternal valves paler.

LUZON, Tayabas Province, Candelaria, altitude 50 meters, June 21, 1930, in small ferns at side of stream (McGregor and Rivera); holotype, male; allotype, female; paratypes, 2 females.

Gonomyia (*Lipophleps*) *ptilostenella* is most closely related to *G. (L.) ptilostenoides* Alexander (Formosa), differing conspicuously in the coloration and details of venation, such as the developed prearcular region. The discovery of the male sex of the present species shows that this group of crane flies is to be retained in *Lipophleps* for convenience only, since the genitalic and antennal structure of the male is much more like that found in *Progonomyia* and *Ptilostena* than in *Lipophleps*. It seems possible that a new subgeneric group, near *Ptilostena*, might prove necessary to receive this species and allies.

GONOMYIA (LIPOPHLEPS) ACANTHOPHALLUS sp. nov. Plate 1, fig. 20; Plate 3, fig. 43.

General coloration dark brown; head gray; scutellum obscure yellow, dark at base; legs black; wings brownish yellow, the stigma a trifle darker; Sc long; male hypopygium with the dististyle single, subterminal in position; phallosome very large and complex, the largest lobe fan-shaped, with a row of spines down the face.

Male.—Length, about 3.3 millimeters; wing, 3.8 to 4.

Rostrum brownish yellow; palpi black. Antennæ black throughout. Head dark gray, the occiput restrictedly paler.

Mesonotal præscutum and scutal lobes dark brown, the anterior lateral pretergites light yellow; median region of scutum and scutellum obscure yellow, the base of the latter dark brown; postnotal mediotergite dark brown, with a yellow area on cephalic lateral portion. Pleura dark brown, with a broad silvery white longitudinal stripe; pteropleurite light yellow. Halteres dusky, the knobs obscure yellow. Legs with the fore and middle coxæ brown, the posterior coxæ a little paler; trochanters pale; remainder of legs black, the femoral bases a little paler. Wings (Plate 1, fig. 20) brownish yellow, the stigmal region a trifle darker but very diffuse; veins brown. Venation: Sc long, Sc₁ ending about opposite one-third the length of the long Rs, Sc₂ a short distance from its tip; branches of Rs long; cell 1st M₂ closed; m-cu at fork of M.

Abdominal tergites dark brown, the sternites obscure yellow. Male hypopygium (Plate 3, fig. 43) with the basistyles, *b*, stout, the outer lateral angle produced into a cylindrical fleshy setiferous lobe. Dististyle, *d*, single, a trifle longer than the lobe of the basistyle, entirely pale, slightly expanded and angularly bent at about three-fourths the length, terminating in a fasciculate seta. Phallosome, *p*, large and complex, terminating in three lobes, one short and obtuse, entirely glabrous; another a long straight rod; the third a broadly expanded, fan-shaped structure, down the face of which extends a row of recurved spines that gradually decrease in size toward the base.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 3 to 5, 1930, by sweeping (*Clagg*); holotype, male; paratype, 1 alcoholic male.

Gonomyia (*Lipophleps*) *acanthophallus* is very different from the other described *Lipophleps* with long subcosta. It is closest to *G. (L.) longiradialis* Alexander (Luzon) in the structure of the basistyle and dististyle of the male hypopygium, but differs very notably in the details of the phallosome.

Genus ERIOPTERA Meigen

ERIOPTERA PERPICTULA sp. nov. Plate 1, fig. 21; Plate 3, fig. 44.

General coloration of mesonotal præscutum and scutum reddish brown; posterior sclerites of mesonotum dark brown; pleura variegated dark and pale brown; halteres pale yellow; wings cream yellow, with a handsome brown pattern.

Male.—Length, about 3.2 millimeters; wing, 4.

Rostrum brown; palpi dark brown. Antennæ short, the segments with long, conspicuous verticils. Head pale ochereous.

Pronotum and anterior lateral pretergites chiefly white. Mesonotal præscutum pale reddish brown, the humeral region more whitish yellow; scutal lobes reddish brown; scutellum and postnotum brownish black. Pleura variegated longitudinally with dark brown and obscure brownish yellow. Halteres pale yellow. Legs with the fore and middle coxæ dark brown, the posterior coxæ paler; trochanters yellow; remainder of legs broken. Wings (Plate 1, fig. 21) cream yellow, with a handsome brown pattern, distributed as follows: Arcular region; a large area at origin of *Rs*, extending from *Sc* to *M*; a broad oblique cross-band along the cord, extending from the stigmal region to *Cu*, wider in the radial field, narrowly interrupted at the fork of *M*; outer end of cell 1st *M*₂; marginal spots on veins *R*₅, *M*₃, *M*₄, *Cu*₁, and 2d *A*; conspicuous grayish brown clouds in the

basal portions of cells M and Cu and the central portion of cell 1st A; veins pale yellow, darker in the infuscated areas. Macrotrichia of veins and marginal fringes very easily broken, leaving microscopic peglike spines. Venation: Sc_1 very long, Sc_2 being just beyond the origin of Rs; Rs subequal to R_{3+4} ; R_{2+3} subperpendicular; R_{2+3+4} in alignment with R_4 ; cell 1st M_2 symmetrically closed; m-cu at fork of M; tips of veins M_3 , M_4 , and Cu_1 deflected very slightly toward wing tip; vein 2d A straight.

Abdominal tergites dark brown, the sternites somewhat paler; hypopygium yellow. Male hypopygium (Plate 3, fig. 44) with the basistyle, *b*, very long and slender. Dististyles two, terminal in position, the outer, *od*, a long straight or gently sinuous blackened rod, at apex a little dilated and set with blunt tubercles. Inner dististyle a slightly shorter pale blade, slightly dilated at distal end. Gonapophyses appearing as simple black spines. *Ædeagus*, *a*, strongly curved.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,800 feet, July 3, 1930 (*Clagg*); holotype, male. "Among ferns and undergrowth along margins of small brook." Mount Apo, Bakraeyon, altitude 8,000 feet, dancing over a rotten log, September 15, 1930 (*Clagg*); paratypes, 15 of both sexes.

I am undecided as to the strict systematic position of this fly and for the present, at least, would place it in *Erioptera*. The essential characters of the fly do not seriously disagree with those of *Erioptera*, although the meral region is somewhat less developed than in most of the subgeneric groups.

TOXORHINA (TOXORHINA) DENDROIDEA sp. nov. Plate 1, fig. 22; Plate 3, fig. 45.

Size small (wing, male, 4.2 millimeters); mesonotum brownish ocherous, more grayish behind, unmarked; wings with cell M_2 open by atrophy of m; male hypopygium with a dense area of dendroidal setæ on mesal face of basistyle; outer dististyle bifid; branches of *ædeagus* short.

Male.—Length (excluding rostrum), about 3.8 millimeters; wing, 4.2.

Rostrum brown, the apex broken in the unique type. Antennæ black. Head gray; eyes (male) very large, broadly contiguous beneath.

Mesonotal præscutum and scutal lobes brownish ocherous, without markings; median area of scutum, base of scutellum and postnotal mediotergite light gray; posterior margin of scutellum ocherous. Pleura ocherous, sparsely pruinose. Legs with the coxæ and trochanters yellow; remainder of legs black.

Wings (Plate 1, fig. 22) hyaline; veins dark brown. Macrotrichia on all longitudinal veins beyond cord, on entire length of Rs, on distal half of M, and distal eighth of basal section of Cu₁. Venation: Sc₁ ending a short distance beyond origin of Rs, Sc₂ a corresponding distance before this origin; cell M₂ open by atrophy of m; m-cu at fork of M, about one-third longer than the distal section of Cu₁.

Abdomen brownish ocherous. Male hypopygium (Plate 3, fig. 45) with the basistyles, *b*, having the mesal face densely set with setigerous punctures, the majority of which bear remarkable branched spinous setæ of many forms (Plate 3, fig. 45, *ds*, sub). Outer dististyle, *od*, bifid, the outer arm a slender, acutely pointed blade, the inner arm stouter, straight, its obtuse apex narrowly blackened. Inner dististyle a broad pale blade, at near midlength on outer margin with a blunt tubercle that bears about a dozen spines; apex of style obtusely rounded. Branches of ædeagus, *a*, short.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, July 2, 1930 (*Clagg*); holotype, male. "Among ferns and undergrowth along margins of small brook." Mount Apo, 8,000 feet, September 19, 1930 (*Clagg*); paratypes, males.

Toxorhina (*Toxorhina*) *dendroidea* is most closely allied to *T. (T.) duyagi* Alexander, *T. (T.) montina* Alexander, and *T. (T.) biceps* Alexander, all of Luzon, differing conspicuously in the structure of the male hypopygium. The rather remarkable group of branched setæ on the mesal face of the basistyle is not found in the three related species listed above.

ILLUSTRATIONS

[Legend: *a*, aedeagus; *b*, basistyle; *d*, dististyles; *ds*, dendroidal seta; *g*, gonapophysis; *i*, interbasal process; *id*, inner dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternite; *t*, tergite; *vd*, ventral dististyle.]

PLATE 1

- FIG. 1. *Scamboneura mindanaoensis* sp. nov., wing.
 2. *Dolichopeza* (*Nesopeza*) *spinisternata* sp. nov., wing.
 3. *Limonia* (*Limonia*) *claggi* sp. nov., wing.
 4. *Limonia* (*Limonia*) *synchæta* sp. nov., wing.
 5. *Limonia* (*Limonia*) *pleiades* sp. nov., wing.
 6. *Limonia* (*Limonia*) *pronotalis* sp. nov., wing.
 7. *Limonia* (*Limonia*) *cynotis* sp. nov., wing.
 8. *Limonia* (*Limonia*) *prolixicornis* sp. nov., wing.
 9. *Limonia* (*Limonia*) *pilosicaudata* sp. nov., wing.
 10. *Limonia* (*Limonia*) *davaoensis* sp. nov., wing.
 11. *Limonia* (*Limonia*) *calianensis* sp. nov., wing.
 12. *Limonia* (*Libnotes*) *bellula* sp. nov., wing.
 13. *Heliüs* (*Heliüs*) *trianguliferus* sp. nov., wing.
 14. *Epiphragma* (*Polyphragma*) *fuscinota* sp. nov., wing.
 15. *Epiphragma* (*Polyphragma*) *fulvinota* sp. nov., wing.
 16. *Epiphragma* (*Polyphragma*) *triarmata* sp. nov., wing.
 17. *Adelphomyia carbonicolor* sp. nov., wing.
 18. *Limnophila* (*Dicranophragma*) *retracta* sp. nov., wing.
 19. *Gonomyia* (*Lipophleps*) *ptilostenella* sp. nov., wing.
 20. *Gonomyia* (*Lipophleps*) *acanthophallus* sp. nov., wing.
 21. *Erioptera perpictula* sp. nov., wing.
 22. *Toxorhina* (*Toxorhina*) *dendroidea* sp. nov., wing.

PLATE 2

- FIG. 23. *Scamboneura mindanaoensis* sp. nov., male hypopygium, details.
 24. *Scamboneura davaoensis* sp. nov., male hypopygium, ninth tergite.
 25. *Scamboneura davaoensis* sp. nov., male hypopygium, dististyles.
 26. *Scamboneura davaoensis* sp. nov., male hypopygium, appendage of ninth sternite.
 27. *Dolichopeza* (*Nesopeza*) *spinisternata* sp. nov., male hypopygium.
 28. *Dolichopeza* (*Nesopeza*) *paucispinosa* sp. nov., male hypopygium.
 29. *Limonia* (*Limonia*) *claggi* sp. nov., male hypopygium.
 30. *Limonia* (*Limonia*) *synchæta* sp. nov., male hypopygium.
 31. *Limonia* (*Limonia*) *pleiades* sp. nov., male hypopygium.
 32. *Limonia* (*Limonia*) *cynotis* sp. nov., male hypopygium.
 33. *Limonia* (*Limonia*) *prolixicornis* sp. nov., male hypopygium.
 34. *Limonia* (*Limonia*) *pilosicaudata* sp. nov., male hypopygium.
 35. *Limonia* (*Limonia*) *pilosicaudata* sp. nov., male hypopygium, ninth tergite.

PLATE 3

- FIG. 36. *Limonia* (*Limonia*) *davaoensis* sp. nov., male hypopygium.
37. *Limonia* (*Limonia*) *calianensis* sp. nov., male hypopygium.
38. *Limonia* (*Libnotes*) *bellula* sp. nov., male hypopygium.
39. *Epiphragma* (*Polyphragma*) *fuscinota* sp. nov., male hypopygium.
40. *Epiphragma* (*Polyphragma*) *fulvinota* sp. nov., male hypopygium.
41. *Epiphragma* (*Polyphragma*) *triarmata* sp. nov., male hypopygium.
42. *Gonomyia* (*Lipophleps*) *ptilostenella* sp. nov., male hypopygium.
43. *Gonomyia* (*Lipophleps*) *acanthophallus* sp. nov., male hypopygium.
44. *Erioptera* *perpictula* sp. nov., male hypopygium.
45. *Toxorhina* (*Toxorhina*) *dendroidea* sp. nov., male hypopygium.

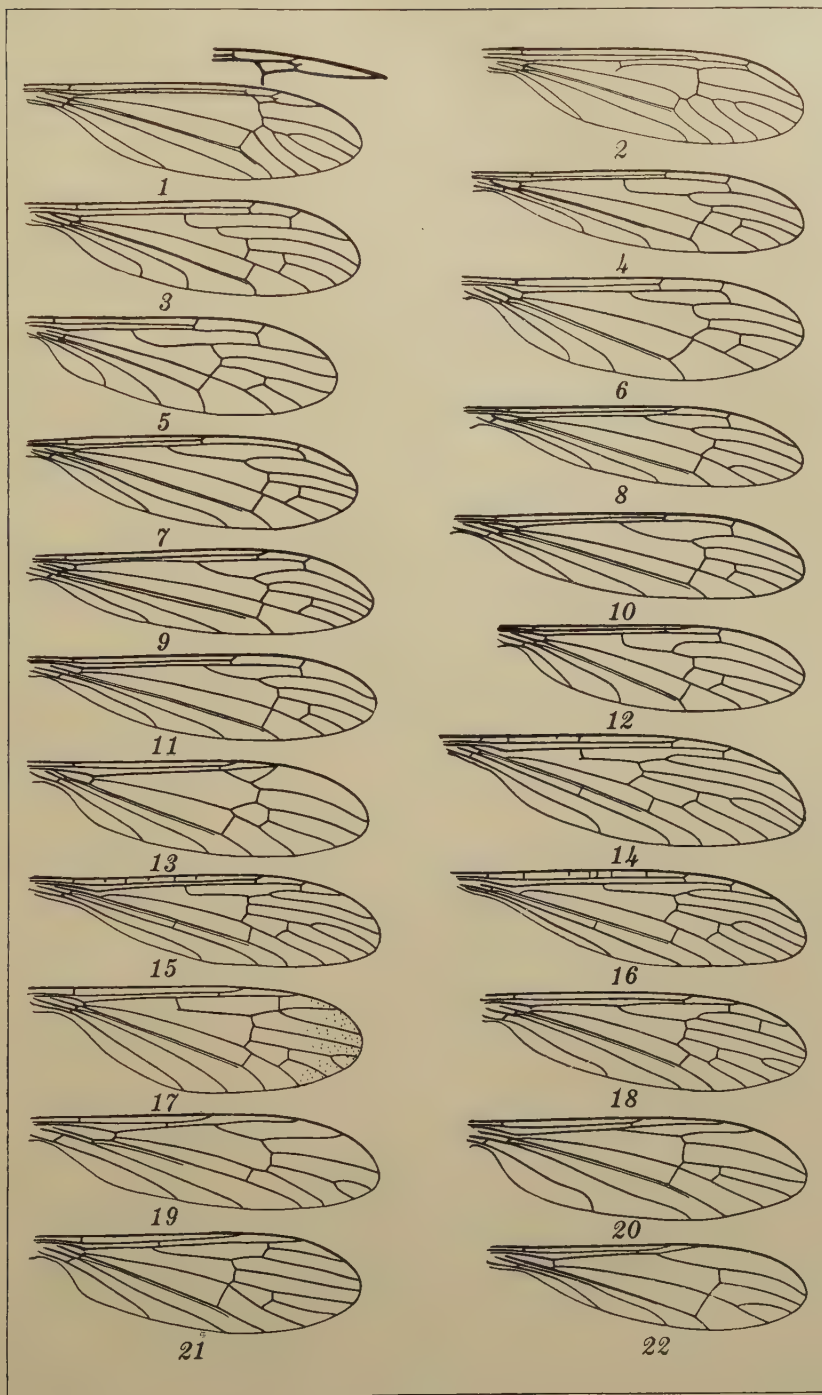


PLATE 1.

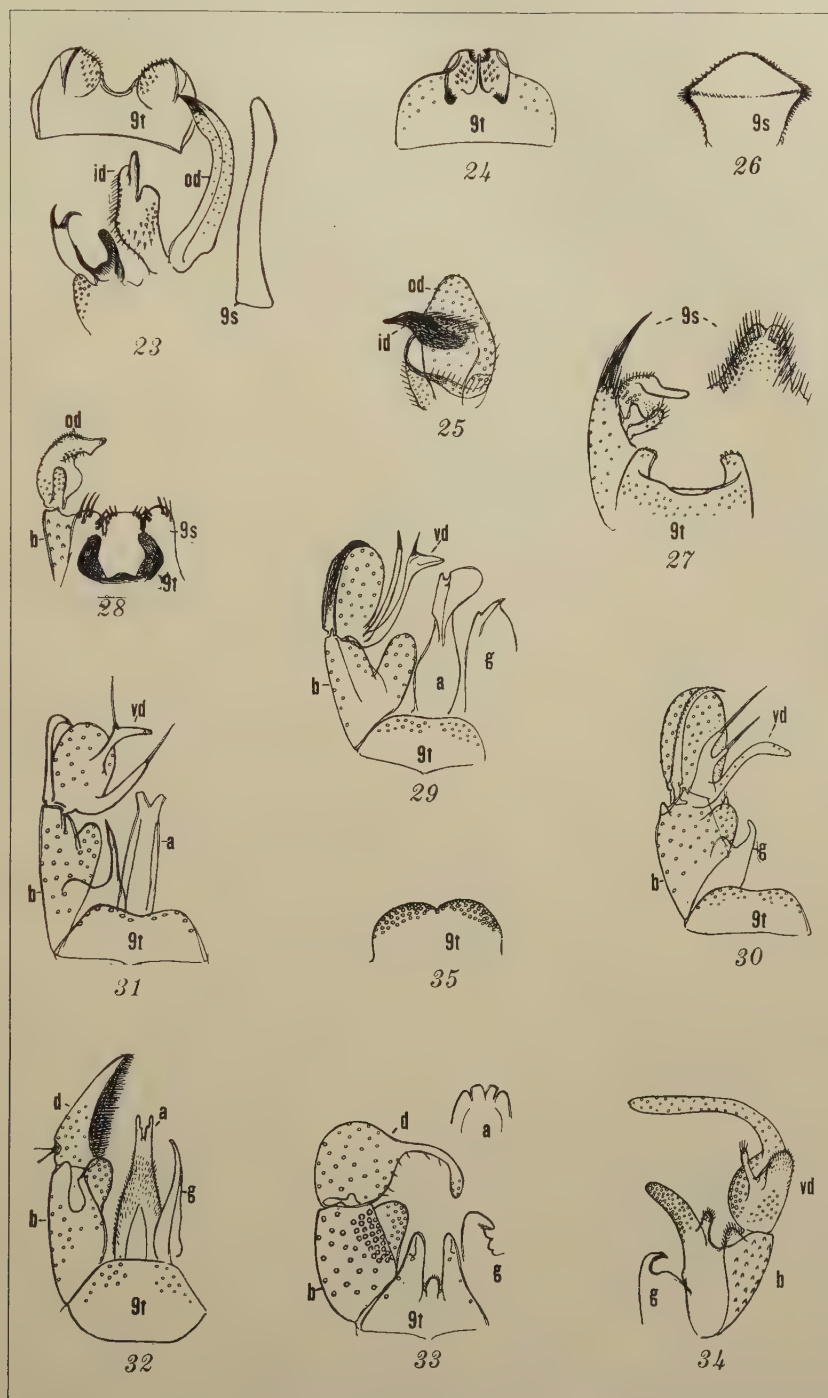


PLATE 2.

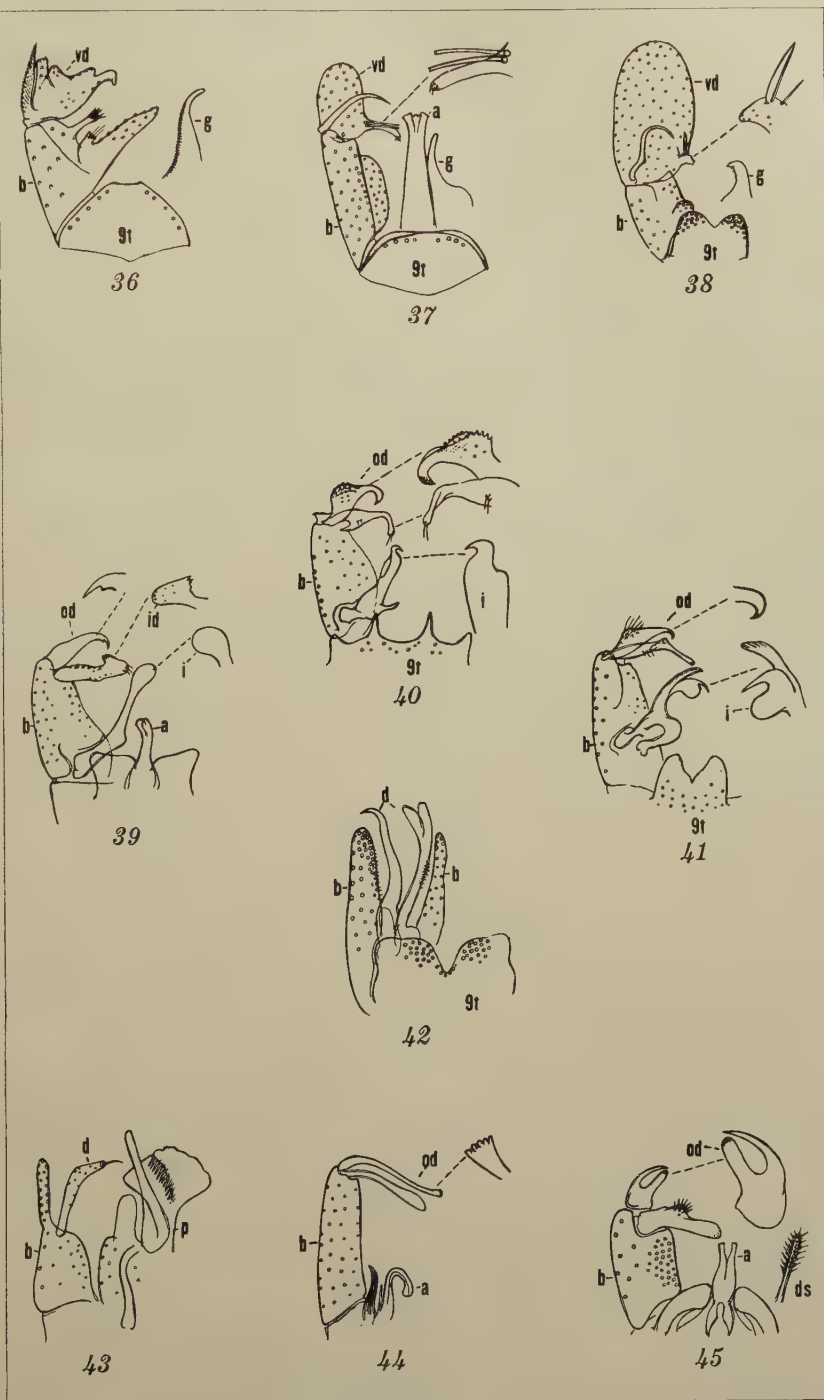


PLATE 3.

MORPHOLOGY OF THE MALE FLOWER OF *COCOS*
NUCIFERA LINNÆUS¹

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THREE PLATES

INTRODUCTION

The coco palm, which is one of the most important crop plants of the Philippines, has been the subject of morphological and agronomical investigations. While the morphological study of the coco palm has had a very interesting beginning, a great deal still remains to be done. The present paper is intended to give an account of the organography of the male flower as well as the morphology of the microsporangium and the microspore. Although the results herein presented may not show wide divergence from the sequence usually found among monocotyledonous plants, they certainly are of value in pointing out variation within a given group.

A recent morphological and cytological work on *Cocos nucifera* is that by Juliano(6) who described and figured the development of the inflorescence, the female flower, and the stony layer. This work was followed by an account of the development of its megasporangium and megagametophyte by Quisumbing and Juliano.(8)

While working on extensive experiments on the germination and viability of the microspores of the coco palm, Aldaba(1) observed that the majority of the male flowers begin to open at about 6 o'clock and dehisce at about 8 o'clock in the morning. The microspores germinated in 5 to 30 per cent sugar solution, and remained viable from two to nine days after they were dehisced. Recently, Santos(10) wrote an account of the reduction division of the microspore mother cell and reported that the coco palm has sixteen bivalent chromosomes that split

¹ Experiment-station contribution No. 715.

lengthwise at the same time. The daughter nuclei resulting from the first division do not pass into anything resembling the typical resting condition but soon reorganize and prepare for the homotypic division. So far as the writers are aware, no work has been done on the morphology of the male flower except the studies noted above.

MATERIALS AND METHODS

Most of the material was collected from October to November, 1926,² from the Bacomo coconut plantation, College of Agriculture, Los Baños, and was killed and fixed in the field and in the laboratory. Microspore material was gathered from trees in the coconut grove adjoining the college campus, in October, 1930. Several killing agents were tried, among which were chromo-acetic stock, formalin-acetic-alcohol,⁽²⁾ and warm corrosive sublimate. The first two killing agents proved to be very satisfactory for our purpose. The material was embedded in paraffin in the usual fashion and sections were cut 7 to 10 microns in thickness. Most of the preparations were stained in Haidenhain's iron-hæmatoxylin and counterstained with orange gold dissolved in clove oil, while Flemming's triple stain and safranin-light green combination were utilized also to advantage.

MALE FLOWER

The male flower is borne either singly or in groups of two or three in the axil of each tertiary bract on the rachillæ (lateral branches) of the inflorescence. This tertiary bract is a tiny collarlike structure subtending the male as well as the female flowers. Often the male flower is intermixed with the female flower in the axil of the basal tertiary bract. The individual male flower is sessile, and can be easily distinguished from the basal female flower by its size and position, and it usually matures first. It is very much smaller than the female flower, ranging from 1 to 2.5 centimeters in length, and 0.3 to 0.6 centimeter in breadth. It is unsymmetrical in shape and pronouncedly angular in transverse section (Plate 2, fig. 8). It possesses six floral envelopes, the morphology of which has

² Delay in the preparation of this manuscript for publication was due to the appointment of the junior author as a Fellow of the National Research Council of America from 1926 to 1928, and severance of his connection with the College of Agriculture upon his return to the Islands in 1928. In that year the senior author was appointed a Fellow of the University of the Philippines, and studied abroad from 1928 to 1930.

been worked out by Möbius.(7) The three outer perianth segments, the sepals, are small, valvate, and triangular. They alternate with the three inner perianth segments, the petals, which are oblong and acute. The edges of the petals fit together up to the opening of the flower. Inclosed by these six perianth envelopes, the sepals and the petals, are the six stamens which form a single whorl, one opposite each perianth segment. The stamens are hypogynous and free. The anthers are 4-celled, dorsifixed after dehiscence, elongated, introrse, and provided with vertical dehiscence. The filament is rather stout and cylindrical. At the summit of the receptacle is located a tricarpelled rudimentary pistil with its styles and stigmas distinctly separate. In very few cases(3, 4) the abortive pistil has been observed to become functional, and is rarely absent.(3)

The inflorescence of the coco palm, the development of which has been traced by Juliano,(6) "begins as a protuberance at the axil of the petiole, at the base of which two primary bracts, the outer and inner spathes, respectively, are cut off, the latter outgrowing the former as the inflorescence develops. The main axis, rachis, then cuts off the secondary bracts, at the axils of which primordia of the rachillae (lateral branches) develop. The rachillae, similar to the main axis (rachis), cuts off bracts (tertiary bracts) at the axils of which the flowers arise." Like the female flower, the individual male flower begins its ontogenetic development as an emergence or papillate outgrowth (*p*) in the axil of the tertiary bract (*tb*) of the rachillae (Plate 1, fig. 1). The female and male floral primordia cannot easily be distinguished from each other at this stage. However, most of the floral primordia are males and only a few of the basal ones ever develop into female flowers. The axillary floral primordium then enlarges and later assumes a conical shape. The first floral organs of the male flower to differentiate at the base of the floral primordium are the three sepals (*s*), which appear simultaneously as papillate protrusions (Plate 1, fig. 2). These soon elongate, bend, and cover the apex of the primordium (Plate 1, fig. 3). As soon as the three sepals have developed, the petals (*pt*) arise simultaneously as small papillate humps within the whorl of sepals, and alternating with the latter (Plate 1, fig. 4). They also elongate, pushing their way between the sepals and the floral cone. These cover the apex of the primordium, and later fuse at their margins (Plate 1, fig. 7). These petals are inclosed by the sepals at their juvenile stage, but as the flower enlarges and matures, the petals outgrow the sepals

(Plate 2, fig. 8). This condition is the reverse of that found by the senior author⁽⁶⁾ in the female flower where the petals never outgrow the sepals. Within the petals (Plate 1, fig. 5) are formed the six stamens (*st*) which differentiate as small humps after the petals have been fully formed, and these early differentiate into anthers and filaments (Plate 1, fig. 7). The last floral organ to develop is the rudimentary tricarpedel pistil (*c*) with its style and stigma distinctly separate (Plate 1, fig. 6). In other words, the development of the floral organs of the male flower is acropetal, and they arise as follows: sepals, petals, stamens, and carpels. This development of the floral organs is similar to that found by the senior author⁽⁶⁾ in the female flower and gives us additional evidence in favor of the view taken by Furtado⁽⁴⁾ in which the papery ring (aril) subtending the pistil in the female flower is considered as a modified andrœcium.

MICROSPORANGE

Transversally, the microsporangium at its juvenile stage is nearly triangular in shape, and is composed of a mass of homogeneous isodiametric meristematic cells delimited by an epidermis. Very early it becomes faintly four-lobed (Plate 2, fig. 9) in cross-section and a formation of a vascular strand (*vb*) of the connective becomes apparent. Under the lobes and simultaneous with their appearance, there is the differentiation of a plate of four to six hypodermal cells (Plate 2, fig. 9a) which functions as the archesporium (*ar*). These hypodermal cells can be easily distinguished from the neighboring cells by their conspicuous size, their radial elongation, their large nuclei, and their greater affinity for stains. They form a single row of cells equaling the extent of the length of the anther. These radially elongated archesporial cells all divide almost simultaneously (Plate 2, fig. 10) by periclinal walls forming an outer layer, the primary parietal cells (*pp*), and an inner layer, the primary sporogenous cells (*psp*). By subsequent periclinal divisions of the primary parietal cells, definite concentric parietal tissue is formed (Plate 2, fig. 11 and 12), which may consist of six to eight layers of cells. The outermost layer (*en*) of the parietal tissue early enlarges in both directions, but more so towards the radial side, and forms a distinct layer before the maturation division stage (Plate 2, fig. 13). The inner parietal layers tangentially elongate and become laterally compressed, and this feature becomes more exaggerated and reaches its maximum as the anther matures, especially at the time the microspores are

formed (Plate 2, fig. 14). The two to four innermost layers of the parietal tissue which surround the sporogenous cells (Plate 2, fig. 13) function as the tapetum (*t*), the disorganization of which is concomitant with the microspore mother-cell stage. In this species the authors have not been able to observe a case where the tapetal cells ever become multinucleate as in *Typha*,⁽¹¹⁾ and hence resembles that found in *Eichornia* and *Pontederia*.⁽¹⁴⁾ At the end of the tetrad formation the tapetal cells have fully disorganized and the outer layer of the parietal tissue shows a very peculiar thickening (Plate 2, fig. 14), a feature of the endothecium (*en*).

The development of the parietal tissue is so rapid that the primary sporogenous cells which are at first near the epidermis of the microsporangium, become deeply embedded within it (Plate 2, fig. 11). These primary sporogenous cells directly by division produce the microspore mother cells of about eight to twelve in cross section. These cells are more or less polygonal in outline and fit tightly together. Their cytoplasm is dense, and their nuclei comparatively large, somewhat spherical with well-defined nuclear membrane. About the time the tapetum shows sign of disintegration, the microspore mother cells (Plate 3, fig. 15) and their nuclei enlarge and greatly differentiate from the adjoining parietal cells (Plate 2, fig. 13). This growth is accompanied by the rounding of the cells, separation from one another, and thickening of their walls (Plate 3, fig. 16). The chromatin assumes a beaded structure and then passes into the synaptic stage, which has been frequently described in microspore mother cells.

The subsequent divisions of the microspore mother cells have been described by Santos,⁽¹⁰⁾ so that any attempt to redescribe them would be superfluous. The main interesting point that we desire to emphasize here is the fact that not all the microspores derived from the divisions of the microspore mother cells become functional. In transverse sections of nearly mature anthers, one may find one of the microspores (tetrad) exhibiting a very distinct nucleus (Plate 3, fig. 20), in others only two (Plate 3, fig. 21), while in the rest there are three (Plate 3, fig. 22). If microspores that are being dehiscent are examined in water, some of them are apt to be found devoid of granular contents and therefore sterile. These sterile microspores never become spherical in water, and their longitudinal sutures persist. They are usually much smaller than the fertile microspores. A very interesting formation of the microspores has

been reported by Juel⁽⁵⁾ in *Carex acuta* where the cell plate which is formed at early divisions is soon reabsorbed, three of the nuclei degenerate, and only the fourth nucleus remains functional.

The division of the microspore mother cell is simultaneous as shown in Plate 3, figs. 17 to 19, and reported by Santos.⁽¹⁰⁾ In a majority of the investigated genera belonging to the same family, the division of the microspore mother cell is also simultaneous, as is true in *Chamaedorea sartorii*, *Ch. glaucophylla*, and *Ch. karwinskiana*,⁽¹⁵⁾ *Chamaedorea corallina*, *Areca triandra*, *Caryota* sp., and *Pterygospermum* sp.⁽¹²⁾ In *Nipa fruticans* Radermacher⁽⁹⁾ reports that the microspore mother cell forms a dyad which divides to form the tetrad. Sometimes only one of the dyads divides so that three to four microspores are formed in a row (linear). After a short period of adherence in tetrads the microspores round off and acquire their coats. They are spherical and smooth. When dry they are ellipsoid and possess a single meridional groove or suture.

While the microspores are yet within the microsporangium, nuclear division takes place which gives rise to the tube nucleus (*t'*) and a generative cell (*g*) (Plate 3, fig. 24). In this condition, as is true of *Sarracenia purpurea*⁽¹³⁾ and other species, the microspores are shed. The generative cell is lenticular in shape, and its elongated and oblong nucleus stains heavily, possessing denser and less regular chromatin. The tube nucleus is very much larger than the generative cell, and possesses a scanty chromatin network and large nucleolus.

SUMMARY

In *Cocos nucifera* the development of the floral primordia of the male flower is concomitant with that of the female flower. Most of the floral primordia developed on the rachillæ (lateral branches) of the rachis (main axis) become male flowers and only a few of the basal ones, female flowers.

The organs of the male flower arise in acropetal succession; namely, sepals, petals, stamens, and carpels.

The stamen early differentiates the microsporangium and the filament. Simultaneous with the formation of the lobes of the microsporangium, a plate of a single row of four to six archesporial cells is formed, and these cells divide periclinally forming the primary parietal layer and the primary sporogenous cells.

The primary parietal layer gives rise to six to eight layers of parietal cells, the outer layer of which becomes the endothecium, while the two to four innermost layers function as the

tapetum. No multinucleate tapetal cells have been observed in *Cocos nucifera*. The intermediate layers of cells may persist in the mature anther.

By subsequent divisions the primary sporogenous cells give rise to the microspore mother cells which divide simultaneously as is generally true of many of the investigated genera of palms. Not all of the microspores (tetrad) become functional.

Division of the microspore nucleus takes place within the microsporangium and the microspore is shed containing a tube nucleus and a lenticular generative cell.

BIBLIOGRAPHY

1. ALDABA, V. C. The pollination of coconut. *Philip. Agriculturist* 10 (1921) 195-207.
2. CHAMBERLAIN, C. J. *Methods in Plant Histology*. Chicago (1924) 349.
3. FURTADO, C. X. A study of the coconut flower and its relation to fruit production. *Garden's Bull., Strait Settlements* 3 (1924) 261-274.
4. FURTADO, C. X. Teratological notes. *Gardens' Bull., Strait Settlements* 4 (1927) 78-86.
5. JUEL, H. O. Beiträge zur Kenntniss der Tetradbildung. *Jahrb. Wiss. Bot.* 35 (1900) 636-659.
6. JULIANO, J. B. Origin, development, and nature of the stony layer of the coconut (*Cocos nucifera* Linnæus). *Philip. Journ. Sci.* 30 (1926) 187-200.
7. MÖBIUS, M. Die Perianthblätter von *Cocos nucifera*. *Bericht. deutsch. Bot. Gessellsch.* 26a (1908) 115-124.
8. QUISUMBING, E., and J. B. JULIANO. Development of ovule and embryo sac of *Cocos nucifera*. *Bot. Gaz.* 84 (1927) 279-293.
9. RADERMACHER, A. Die Gametophyten von *Nipa fruticans* und *Actinophloeus macarthurii* Becc. Msc., sowie ein versuch die Systematik der Angiospermen durch die Haploid Generation zu ergänzen. *Ann. Jard. Bot. Buitenzorg* 35 (1924) 1-54.
10. SANTOS, J. K. A cytological study of *Cocos nucifera* Linnæus. *Philip. Journ. Sci.* 37 (1929) 417-437.
11. SCHAFFNER, J. H. The development of the stamens and carpels of *Typha latifolia*. *Bot. Gaz.* 24 (1897) 93-102.
12. SCHNARF, K. *Embryologie der Angiospermen*. Berlin (1929) 673.
13. SHREVE, T. The development and anatomy of *Sarracenia purpurea*. *Bot. Gaz.* 42 (1906) 107-126.
14. SMITH, W. R. A contribution to the life history of the Pontederiaceae. *Bot. Gaz.* 25 (1898) 324-337.
15. SUESSENGUTH, K. Beiträge zur Frage des systematischen Anschluss der Monokotylen. *Beih. Bot. Centralbl.* 38² (1921) 1-79.

ILLUSTRATIONS

PLATE 1. *COCOS NUCIFERA* LINNÆUS

- FIG. 1. A longitudinal section of a portion of a rachilla showing male floral primordia (*p*); $\times 53$.
2. Longitudinal section of a male flower showing the beginning of the sepal (*s*); $\times 53$.
3. Longitudinal section of a male flower with the three sepals (*s*) already developed; $\times 53$.
4. Longitudinal section of an older male flower showing the beginnings of the petals (*pt*); $\times 53$.
5. Longitudinal section of a much older male flower showing the sepals (*s*) and petals (*pt*) already developed, and the beginning of the stamens (*st*); $\times 53$.
6. Portion of a longitudinal section of a male flower showing the stamens (*st*) and carpels (*c*) developing; $\times 53$.
7. Longitudinal section of a male flower showing all its parts already formed; $\times 53$.

PLATE 2. *COCOS NUCIFERA* LINNÆUS

- FIG. 8. Lateral view of an unopened mature male flower showing its perianth segments; $\times 6$.
9. Diagram of a transverse section of a young anther showing lobation and vascular bundle (*vb*) to the connective; $\times 66$. 9a, portion taken from fig. 9 showing the plate of archesporial cells (*ar*); $\times 706$.
10. Division of the archesporial cells to form the primary parietal cells (*pp*) and the primary sporogenous cells (*psp*); $\times 706$.
11. Portion of the anther showing the thick parietal tissue, the sporogenous cells (*sp*), and the tapetum (*t*); $\times 326$.
12. Longitudinal section of a young anther showing sporogenous cells (*sp*) and the parietal tissue to the right; $\times 706$.
13. Portion of a transverse section of an anther showing the parietal tissue, microspore mother cells (*mimc*), and the disintegrating tapetum (*t*); $\times 593$.
14. Transverse section of a mature anther before dehiscence, showing the microspores (*mi*), endothecium (*en*), stromium (*st'*), and portion of the remains of the intermediate cells of the parietal tissue; $\times 156$.

PLATE 3. *COCOS NUCIFERA* LINNÆUS

- FIG. 15. Microspore mother cell in resting condition; $\times 706$.
16. Microspore mother cell in diakenetic stage; $\times 706$.
17. Microspore mother cell in heterotypic telophase; $\times 706$.
18. Homotypic metaphase; $\times 706$.

FIG. 19. Homotypic metaphase; $\times 706$.

20. Tetrad showing only one of the microspores possessing distinct nucleus; $\times 706$.
21. Tetrad, only one of the microspores devoid of a nucleus; $\times 706$.
22. Tetrad, all microspores functional; $\times 706$.
23. Microspore before dehiscence showing distinct entire and exine; $\times 706$.
24. Longitudinal section of the microspore at shedding stage; note the tube nucleus (*t'*) and the lenticular generative cell (*g*); $\times 706$.

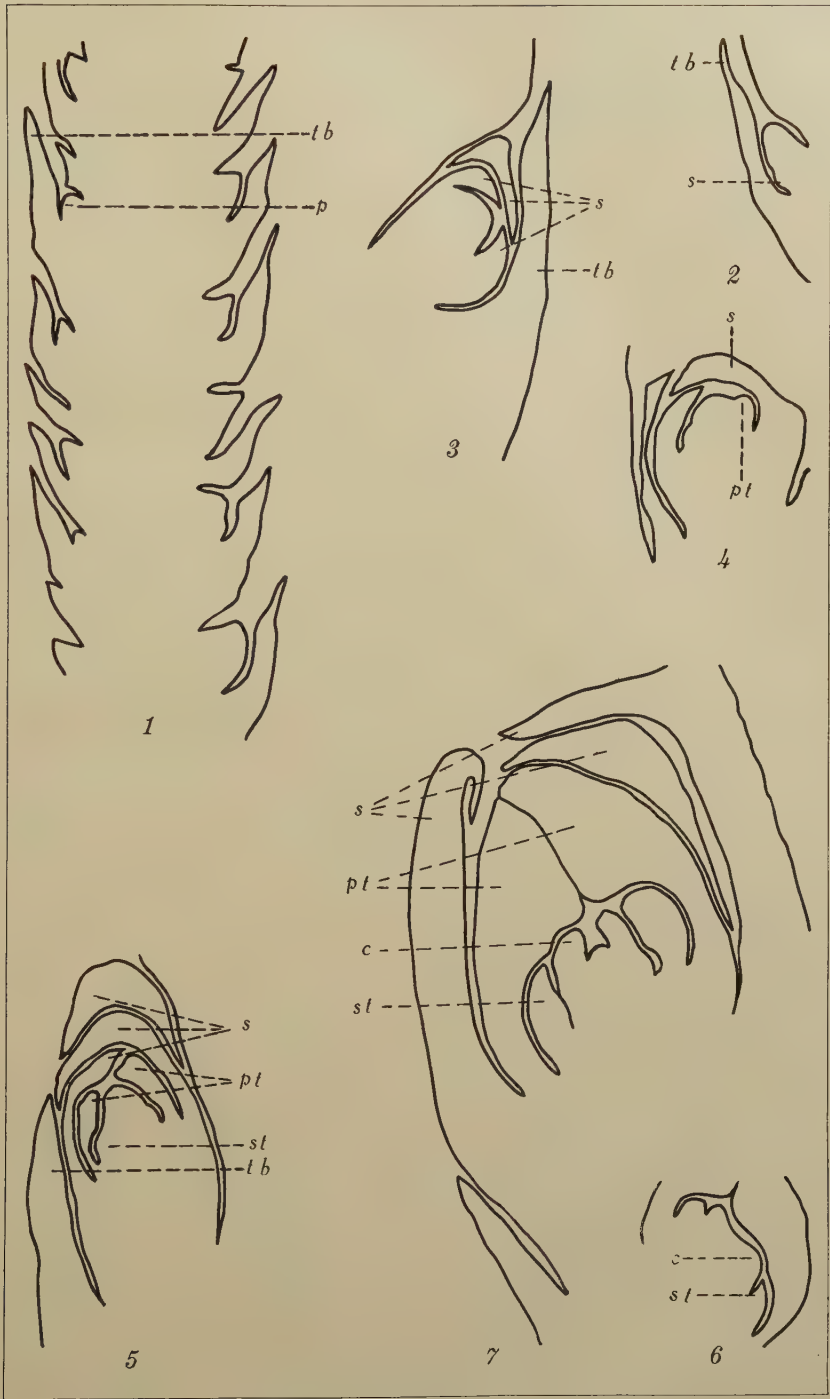


PLATE 1.

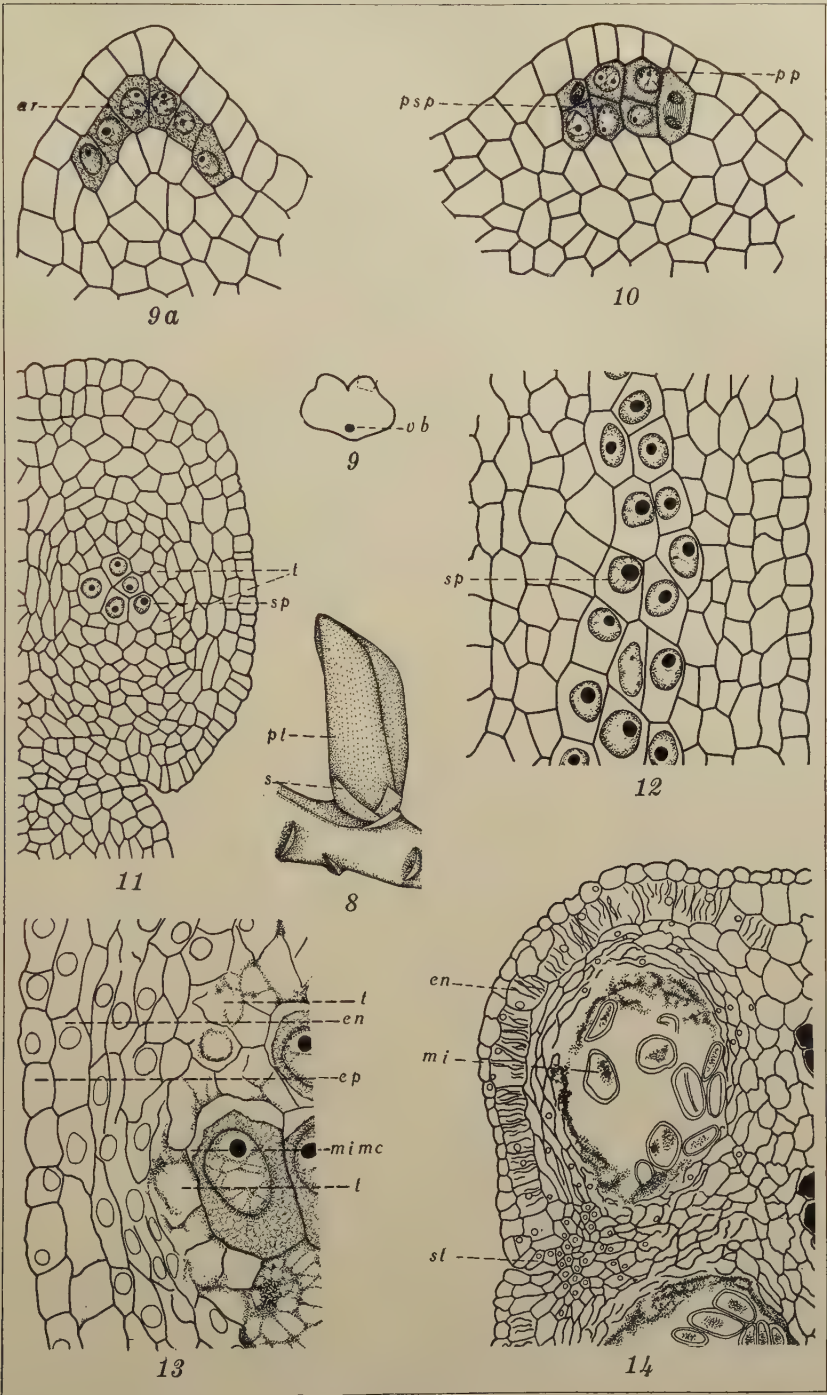


PLATE 2.

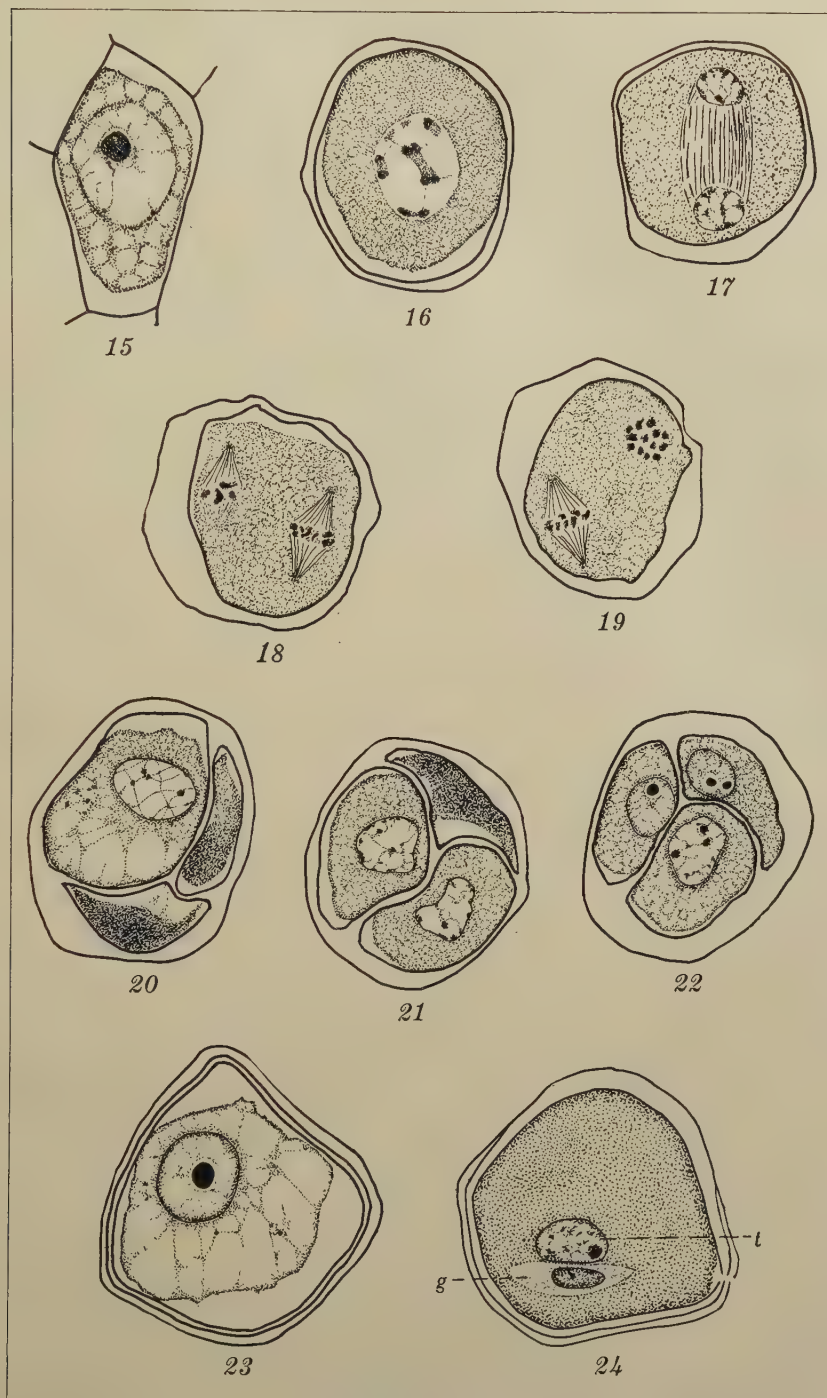


PLATE 3.

LEPROSY IN CEBU, I

By JOSÉ RODRIGUEZ
Of the Philippine Health Service

TWO TEXT FIGURES

GEOGRAPHICAL CONSIDERATIONS AND POPULATION

Cebu is an elongated island barely 36 kilometers at its widest point with a length of 223 kilometers and a total area of 4,836 square kilometers. Its long axis trends north-northeast and south-southwest, and the mainland lies between $123^{\circ} 17' 34''$ and $124^{\circ} 4' 4''$ east longitude and $9^{\circ} 24' 46''$ and $11^{\circ} 17' 11''$ north latitude.

The island is bounded on the north by the Visayas Sea, on the east by the Camotes Sea and Bohol Strait, on the south by the Mindanao Sea, and on the west by the narrow Tañon Strait which separates it from Negros. The province comprises a considerable number of minor islands, of which only fourteen have an area of one square mile or over. The more important of these are Bantayan, Mactan, Poro, Paaian, and Ponson.

Although mountains extend almost throughout the entire length of Cebu, their altitude is not great, compared with the towering ranges in the surrounding islands. In reality, this island is the lowest of the larger Visayan islands. This fact has a decisive influence on the climate of Cebu, which will be discussed later.

The highest peak is Mount Uling, 1,013 meters, found in the central part. From this peak, the land slopes down gradually on all sides to form the central plateau which has one of the most fertile soils in Cebu.

The coastal plains are very narrow, widening out only around the city of Cebu and at the town of Tuburan. There is also a fairly rich plain towards the north, where Bogo is located. These plains form one of the most thickly populated regions in the Philippines.

The soil is porous and so thin that the coral subsoil crops out on the surface even in the most fertile regions. This character of the soil, together with the scanty rainfall, makes Cebu unfavorable for rice growing. Corn, the staple food of the

people of Cebu, grows very well, so that three harvests a year are possible in most parts of the island. Other products are coconuts, sugar cane, peanuts, bananas, pineapples, camotes, maguey, and kapok.

The physiography of the island affords very few rivers, which become veritable torrents washing down the soil of the highlands to the coastal plain below shortly after heavy rains, but dwindle to mere rivulets in the dry part of the year. Wells are deep and difficult to dig, so that in most places water for bathing purposes is difficult to obtain and the populace in the past had to depend on rain for drinking water.

The difficulty of obtaining a water supply does not encourage bathing among the people and the masses are dirty as a rule, and skin diseases of all kinds are very common. This unfortunate condition has been much improved during the last few years through the building of waterworks and the drilling of artesian wells in the more important towns. There are at present 583 artesian wells serving 290,000 people, and 25 water works, serving 400,000 inhabitants. In addition, there are 547 sanitary dug wells, serving 85,000 people, and 510 insanitary dug wells serving another 100,000.

According to the census of 1918, there is a total of 252,316 hectares of agricultural land, of which only 128,819, or 51.1 per cent, was under cultivation in that year. From personal observation, however, it is quite apparent that all the arable and much of the poor land is under cultivation, and even the steep hillsides are planted to corn and other products.

The island is rich in minerals, the most important being coal and gold. The government cement plant at Naga turns out good cement and the supply of crude material is unlimited.

Good fishing banks are found along the coast. The inhabitants of a few of the municipalities, such as Bantayan and Cordova, depend almost entirely on fishing for their living. Hogs and goats are raised for local consumption. Chickens and eggs are exported to Manila. Tuba, a fermented drink from the coco palm, is consumed in large quantities in many localities.

According to population, Cebu is the most important province in the Philippines. In the last census, that of 1918, the population was placed at 855,065. In the 1903 census, it was 653,727, representing an increase of 30.8 per cent in fifteen years, or 2.1 per cent per year. Thus the increase is considerable, in spite of continuous emigration to neighboring provinces—Leyte, Samar, Occidental Negros, and Oriental Negros—as well as to Min-

doro, Mindanao, and Hawaii. During the nineteenth century, the population of Cebu showed remarkable increases. The following figures were obtained from Buzeta and Bravo; 100,000 inhabitants in 1799; 334,790 in 1846; and 389,073 in 1850.

In 1898, Lebres gave the official population as being around 520,000. The estimated population of the province, according to figures available at the District Health Office, was 994,365 on December 31, 1929.

CLIMATE

There is one first-class meteorological station located at the capital and five rain stations in different parts of the province. The Dalaguete, Cebu, and Bogo stations are located in the southern, middle, and northern portions of the eastern coast, respectively, and are all practically at sea level. The station at Biaong Cui's Farm, within the jurisdiction of the town of Barili, is the most elevated, 60 meters, and is located on a slope of the central ridge. The only station on the western coast of the island is located at Tuburan. A coöperative station was established at Talisay in May, 1928.

The climate of Cebu is determined chiefly by the low altitude of its mountains and its location in the central Visayas region, surrounded by a number of islands covered by high mountain ranges. The mountains of Negros precipitate most of the rain during the southwest monsoon, while the high ranges of Samar and Leyte cut off the moist winds during the northeast monsoon. This makes the rainfall scanty, and the province is one of the driest in the Philippines. However, this rainfall is very evenly distributed, and this makes the climate suitable for corn and other products.

The data used in the following discussion were obtained directly from the Weather Bureau and from the 1918 census.

Temperature.—The various stations in the province show only slight differences in the temperature. For this reason the data for Cebu, the oldest station, will be used as the basis for the discussion on the climate. When there exist notable differences between various stations, these will be mentioned.

Table 1 gives the normal monthly and annual temperatures for all the stations, and Table 2 shows the means of the annual extreme temperatures.

The tables reveal no marked change in the temperature variations in the different stations throughout the year. As is to be expected, there is a higher mean annual range of temperature as well as mean absolute annual range for the Biaong Cui's Farm

TABLE 1.—*Showing the normal monthly and annual temperatures and the mean annual ranges in C°.*

Station.	Mean annual range.	January.	February.	March.	April.	May.	June.
Dalaguete.....	2.1	26.2	26.5	26.9	28.2	28.3	27.8
Biaong Cui's Farm.....	2.9	24.8	25.1	25.5	27.2	27.7	27.4
Cebu.....	2.1	26.0	26.0	26.8	27.7	28.1	27.8
Tuburan.....	2.9	25.5	25.5	26.1	27.5	28.4	28.0
Bogo.....	2.5	26.7	27.0	27.5	28.9	29.2	28.2

Station.	July.	August.	September.	October.	November.	December.	Average.
Dalaguete.....	27.6	27.8	27.8	27.6	27.2	26.6	27.4
Biaong Cui's Farm.....	26.9	27.4	27.0	26.7	26.1	25.4	26.6
Cebu.....	27.4	27.5	27.3	27.1	26.8	26.5	27.1
Tuburan.....	27.8	27.9	27.4	27.2	27.7	26.0	27.0
Bogo.....	27.8	27.9	27.9	27.7	27.6	26.8	27.7

TABLE 2.—*Showing the means of annual extreme temperatures and the mean absolute annual range in C°.*

Temperature.	Dalaguete.	Barili.	Cebu.	Tuburan.	Bogo.	Average.
Maximum.....	34.8	35.9	33.8	35.6	35.6	35.1
Minimum.....	20.2	19.6	20.4	18.1	21.3	19.9
Mean absolute range.....	14.6	16.3	13.4	17.5	14.3	15.2

Station, which is located at a higher altitude than the others. The corresponding figures for Tuburan on the western coast are also higher than those for Cebu, Dalaguete, and Bogo on the opposite coast, showing that there is a wider variation of temperature on the western than on the eastern side of the island.

The average means of the upper and lower extremes of temperature for the entire province are 35.1° C. and 19.9° C., respectively, with a mean absolute annual range of 15.2° C. The mean of the maximum annual temperature, although varying with local conditions, is quite in accord with that of the rest of the Visayas, which is generally lower than the corresponding figure for Luzon. On the other hand, the mean of the minimum

annual temperature is higher in the Visayas including Cebu, so that the range of the temperature is lower than in Luzon.

The figures for the daily extremes of temperature are interesting, for although the daily mean maximum temperature for Cebu (30.6°C.) is not very high, compared with Dagupan (30.0°C.), for example, the mean diurnal range is very small, being only 6.6°C. (Dagupan, 10.2°C.) which is the lowest among the ten stations located in the Philippines according to the 1918 census. It is thus demonstrated that although the mean annual temperature for Cebu (27.1°C.) is only slightly higher than the average of 26.9°C. for the entire Philippines, the climate seems warmer than it really is on account of the lack of vegetation, the character of the soil, and the low diurnal range.

The extreme regularity in the sequence of its normal diurnal monthly and annual changes of temperature is remarkable.

Rainfall.—According to the classification of the Weather Bureau, as given in the census of 1918, the monthly distribution of rainfall in the Philippines may be divided into two main types and two other intermediate types, as follows:

First Type: Two pronounced seasons, dry in winter and spring, wet in summer and autumn. Only the cyclonic or summer rainfall prevails, the other being hardly noticeable; hence the dry season of winter lasting from three to six or seven months. This is the type shown by the monthly distribution of rainfall in all the stations on the western part of the islands of Luzon, Mindoro, Negros and Palawan, and the western and southern part of Panay.

Second Type: No dry season; with very pronounced maximum rain period in winter. The regions enjoying this type of climate or of monthly distribution of rainfall are Catanduanes, Sorsogon, the eastern part of Leyte, and a great portion of the eastern part of Mindanao. There is in the regions of this type much cyclonic or summer and autumn rainfall; but the maximum monthly rainfall is generally that of December and January, while the monthly amounts of rain for the summer and autumn months are far from being so great. There is not a single month dry in regions of this type, the minimum monthly rainfall occurring in some places in spring, in other places in summer.

Third or Intermediate A Type: No very pronounced maximum rain period; with a very short dry season, lasting only from one to three months. This type is intermediate between the preceding two, although it approaches more the first type inasmuch as there is a short dry season. Regions with this type of climate are the western part of Cagayan, Isabela and Nueva Vizcaya Provinces, the easternmost part of the Mountain Province. A small portion of southern Tayabas, Masbate, and Romblon, the northeastern part of Panay, the eastern part of Negros, the central and southern part of Cebu, part of Misamis, Agusan and Bukidnon Prov-

inces, the peninsula of Zamboanga, and a good portion of eastern Palawan. The short dry season experienced in regions of this type occurs in some places in winter, in others in spring.

Fourth or Intermediate B Type: No very pronounced maximum rain period and no dry season. This is also an intermediate type between the first and second, but approaching more the second inasmuch as there is no dry season in it. Regions with this type of climate are the Batanes Province, the easternmost part of northern Luzon from Cagayan Province to about one-third of the Tayabas east coast, the western part of Ambos Camarines and Albay Provinces, the Bondoc Peninsula, the eastern part of Mindoro, Marinduque, a small portion of Samar near Calbayog, the western part of Leyte, *the northernmost part of Cebu*, the Islands of Bohol, Jolo, and Basilan, and a great portion of Mindanao, including the Provinces of Lanao, Cotabato, the western part of Davao and Misamis Provinces and the eastern part of Zamboanga Province.

It is thus seen that, according to this classification, the middle and lower thirds of Cebu, including the Dalaguete, Biaong Cui's Farm, and Cebu stations belong to the Third or Intermediate Type A, while the northern third (Tuburan and Bogo stations) falls under the Fourth or Intermediate Type B.

Careful analysis of more recent data obtained from the Weather Bureau appearing in Table 3, which gives the average monthly and annual rainfall of the different stations, raises some doubt as to the accuracy of previous data on which the classification has been based. According to the table, Tuburan situated in the northern third has the lowest annual rainfall, as well as the lowest in any month, there being an average of only 9.9 millimeters for April. During March also it shows a rainfall of less than 50 millimeters (40.9 millimeters). On the other hand, Dalaguete on the southern end of the island has only one month (April) below 50 millimeters (48.0 millimeters). Therefore, there is more of a dry season in Tuburan (northern part) than in Dalaguete (southern part), which is against the classification given above.

Commenting on this, the Director of the Weather Bureau says, in a communication dated November 17, 1928:

According to recent data, it would seem probable that the northern part of Cebu Island will have to be considered as of the Third or Intermediate A Type with no very pronounced maximum rain period and with a short dry season of from one to three months, as those of the central and southern part. Yet we have to wait for more years of observation until this can be definitely decided.

The rainfall is naturally heavier in Biaong Cui's Farm which is on a higher elevation than the other stations. The annual

TABLE 3.—Showing the average monthly and annual rainfall for the various stations in Cebu.

Station.	January.	February.	March.	April.	May.	June.	July.
Dalaguete.....	134.3	81.4	87.8	48.0	115.8	135.6	141.5
Biaong Cui's Farm.....	157.6	104.1	74.0	50.0	121.7	148.5	127.1
Cebu.....	95.0	73.5	48.6	38.6	95.0	180.6	157.1
Tuburan.....	112.3	67.5	40.9	9.9	59.9	180.7	148.5
Bogo.....	133.8	74.6	79.5	36.1	121.3	168.8	204.2

Station.	August.	September.	October.	November.	December.	Annual.
Dalaguete.....	104.4	149.2	158.8	182.5	164.6	1,503.8
Biaong Cui's Farm.....	96.4	149.6	222.8	213.0	194.5	1,659.5
Cebu.....	142.5	189.8	224.9	138.2	146.0	1,529.8
Tuburan.....	99.6	178.1	170.0	153.0	114.5	1,234.9
Bogo.....	136.4	180.5	192.6	232.1	181.1	1,492.1

rainfall for Tuburan is considerably lower than for the three stations on the other side of the island.

In order to show the differences in the distribution of rainfall in Cebu in different seasons of the year, I have added the average rainfall for each station during the four months in which the summer or cyclonic rains are more abundant—namely, June, July, August and September—and compared the total with that for the four other months in which the northeast monsoon (winter) rains occur—namely, November, December, January and February. The result is shown in Table 4.

TABLE 4.—Seasonal average rainfall for all stations in Cebu Island.

Station.	June to September (southwest monsoon).	November to February (northeast monsoon.)
Dalaguete.....	534.7	562.8
Biaong Cui's Farm.....	531.6	669.2
Cebu.....	670.0	452.7
Tuburan.....	556.9	447.3
Bogo.....	689.9	611.6
Average.....	598.6	548.7

The table proves that there is no very pronounced rain period throughout the province. The rainfall is slightly more marked during the northeast monsoon months in Dalaguete and Biaong Cui's Farm, or the southern part of the island. On the other hand, there are more rains during the southwest monsoon period in the northern part. Aside from this, there seems to be no demonstrable difference in the rainfall characteristics of the different parts of the island.

The average annual rainfall throughout the island is low, being only 1,494.0 millimeters, compared with the average of 2,366.1 millimeters for the rest of the Archipelago. This province is one of the driest in the Philippines, and is surpassed in this respect only by Nueva Vizcaya, Misamis, Oriental Negros, and Bohol.

Humidity and cloudiness.—Data for humidity and cloudiness are available only for the capital. Cebu shows the lowest annual mean humidity of all the stations in the Philippines. The mean annual range of oscillation is also very small, so that the atmosphere is comparatively dry in spite of the relatively small size of the island and the large bodies of water around it. This may be attributed chiefly to the low rainfall and scanty vegetation. April is the least humid month, and December is the most humid.

A graphic representation of the monthly and annual mean relative humidity of the city of Cebu, compared with Manila, is given in fig. 1.

The Cebu skies are clear compared with other stations; the mean annual cloudiness is only 5.5 per cent, the lowest among all stations in the Islands except Legaspi.

Summarizing the climatological characteristics of Cebu Island, it may be said that the mean annual temperature is only slightly higher than the average for the Philippines, but due to the low range of the daily, monthly, and annual temperature variations, the climate seems warmer than that of many other provinces in the Philippines. This peculiarity of the Cebu climate has been well known since the Spanish time. The rainfall is scanty and is fairly well distributed throughout the year. The humidity is low with very little seasonal variation. In short, the chief characteristic of the Cebu climate is the little variation in the temperature, rainfall, and humidity from month to month and from year to year.

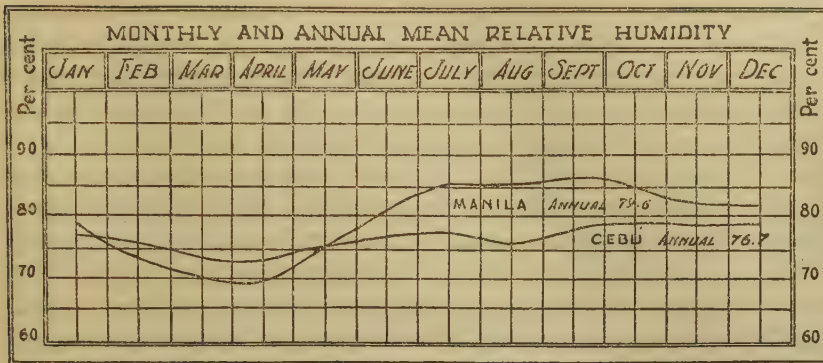


FIG. 1. Monthly and annual mean relative humidity of Manila and Cebu, Philippine Islands.

HISTORICAL SKETCH

The manner in which leprosy was introduced in Cebu and the rest of the Archipelago remains to be fully established. It is now practically certain that those who ascribe the introduction of leprosy to the bringing of 130 Japanese lepers to Manila in 1630 are in error and that leprosy was already prevalent in certain regions before that year. Barely seven years after the occupation of Manila by Legaspi in 1570, Father Juan Clemente, a Franciscan lay brother, was kept busy at the door of the newly established Franciscan church ministering to the needs of numerous patients among whom were many lepers. Lepers were also so numerous in the Bicol provinces of Albay and Sorsogon that a hospital for lepers was established at Nueva Caceres, then the capital of the Bicol region, barely thirteen years after Salcedo explored that region.

The possibility that the disease may have been introduced from the continent by Siamese, Chinese, and Japanese traders has to be kept in mind. Guerrero is inclined to believe that the disease was introduced here by Malay settlers from the Malay Archipelago who in turn got it from their ancient Hindu colonizers.

The disease was also encountered in less-populated provinces; by Comin in Leyte, and by Fray Juan in La Union.

The disease, however, did not gain much headway until quite recently when, with the introduction of better transportation and communication facilities, it spread with alarming rapidity.

The spread of leprosy in Cebu at the beginning of the nineteenth century must have been very rapid. No reference to the disease can be gleaned from official and ecclesiastical reports prior to this time. This was partly due to the fact that the disease was then probably not so prevalent, and partly because the officials were indifferent to such unproductive matters as leprosy. It is certainly to be regretted that the Franciscan Order did not settle in Cebu, as the monks of this order established the first hospitals in the Philippines and for a time were the only ones concerned with the health of the natives. Their chronicles are the only available sources of information regarding leprosy in the early days of Spanish domination.

But by 1817, the lepers had become so numerous that Hospital de San Lazaro had to be built for them by the Bishop Joaquin de Sopotran out of his own funds aided by some donations. By Real Cedula in 1819, it was placed under the patronage of King Ferdinand VII. In spite of royal favor, however, the hospital from the start passed through many vicissitudes and a few years later, partly due to the poor material used in its construction and partly due to the failure of the business where the trust fund had been invested, the building fell in ruins and the patients were thrown out upon the streets.

It was through the efforts of one of the most active bishops that Cebu has ever known, Bishop Romualdo Gimeno, that the building which was in use until as late as 1921 was built. It was inaugurated on April 1, 1854, after five years of construction, a period beset with many difficulties. The funds were derived from the private coffers of the bishop and from donations from the clergy and the faithful, as well as from liberal subsidies from the insular and provincial governments.

The building was of stone and first-class wood, and could accommodate about one hundred lepers.

Segregation of the sexes was effected by a central partition dividing the hospital into two parts. The personnel lived in a separate building which was, however, built so close to the hospital proper as to form almost a single structure with it. To prevent the possibility of contagion through the pestiferous emanations from the patients, a possibility much thought of in those days, the chapel was shut off from the congregation by glass doors.

The purpose of the hospital was to offer a place of refuge for indigent lepers. However, the inmates were free to come and

go, so that there was no segregation in the real sense of the word.

The hospital was maintained as follows: 1,842 dollars (Mexican currency) were obtained from provincial funds, 200 from a savings bank account maintained by friars of the Recollect Order in Manila, 100 from a similar account maintained by the Archbishop of Manila, and from minor donations which amounted to another 100 dollars. The hospital was operated at a considerable deficit, which was covered from the bishop's own funds.

Due to the stability of the above funds and the interest of succeeding bishops, the hospital continued to be the refuge of indigent lepers for over half a century.

In 1886, the Spanish authorities set aside the small island of Paniltugan, one of the lesser islands of the Bantayan group off the northwest coast of Cebu, as a reservation for lepers from the nearby municipalities. Lepers from the municipalities of Medellin, Daanbantayan, Bantayan, and even from San Carlos on the mainland of Negros, were apprehended by local police and brought to the island. Here, they were left to their own devices. Fortunately, the island is fertile and fish are abundant along the shores. On Sundays, the lepers were allowed to beg in the streets of the town of Bantayan which they reached by means of bancas.

It is interesting to record that a number of non-lepers are said to have gone to the island to live with the lepers. Most of them were members of the families of the lepers, although a few voluntarily exiled themselves there to escape the taxes. It is said that five families hid on the island and thus escaped the collections. When a census of the inhabitants of the island was taken in 1907 previous to sending the lepers to Culion, it was discovered that there were 70 persons, of whom only about two-thirds were lepers. None of the rest was known to have developed leprosy subsequently.

In spite of the above measures, the disease increased by leaps and bounds and toward the close of the last century conditions, particularly in the city itself, became alarming. At the instance of the Governor, Inocencio Junquera, Dr. Manuel Rogel Lebres, "medico titular" of the province, made a survey of the lepers begging in the streets of Cebu. Within a few days, he had examined 426. This did not include lepers among the rich nor young children. Furthermore, Lebres averred that as soon as the lepers became aware of this survey, many hid themselves

or left the city and, therefore, were not included in his list. He estimated that there must have been more than 2,000 lepers in the province at the time the survey was made.

For a time the local government considered ways and means to counteract the advance of the disease, but before anything could be done, a prolonged debate was started in local papers, and soon after the Manila periodicals took up the subject.

Rogel Lebres courageously and ably defended his contagionist views and advocated the segregation of the lepers in some of the smaller islets near the coast of the larger islands, but his efforts proved of no avail against the attacks of certain fashionable physicians in Manila who had found it convenient to hold the opposite view. The result was that Lebres was transferred to another district in Bohol Island. Thus was the debate terminated, and the lepers once more were left begging in the streets of Cebu unmolested.

At this juncture, a slight digression may be permitted to describe a book on leprosy written by Rogel Lebres, entitled, *Leprosy in Bisaya*, published in 1897, and considered the best work on the disease published during the Spanish régime. How the author came to write the book is described in the foreword. After his transfer from Cebu to Bohol Province, he was alarmed at the number of lepers he found there. Wishing to know more of the disease, he ordered from Paris as many books on leprosy as could be purchased with a certain sum in pesetas. Due to an error of his intermediary, however, the order was placed in pesos instead of pesetas so that three months later, to his "no little disgust" he received twelve certified packages containing books on leprosy, forming a bulk "which two men could hardly carry." But came the day when with nothing else to read and surrounded by these books, almost by necessity he eventually read through them all and afterwards decided to set down his own ideas in book-form.

His book contains a good presentation of the views on leprosy current at the close of the nineteenth century. His data on the disease as encountered in Cebu and Bohol were first hand and are the only available ones describing conditions in these provinces over thirty years ago. His data on the other provinces were not as complete.

He proposed the complete segregation of all lepers in small islets near the main ones, to be placed in charge of friars, as the only means to stamp out the disease. Needless to say, the idea was not even tried.

The Americans found the streets of the city itself thoroughly infested with leprous beggars, and as early as 1902 efforts were made to round them up and segregate them in the old hospital building and its environs.

In 1907, the lepers collected in the city of Cebu, together with about 300 from other municipalities, were shipped to Culion on two coast-guard steamers, these forming the first group of lepers to be admitted to that colony. Since that first shipment, two collections have been made every year for Culion, the number depending on the number apprehended during the intervals. After the establishment of the Culion Leper Colony, the old leper hospital in Cebu was used as detention camp where the lepers awaiting shipment to Culion were kept.

In 1921, the old building, being in a dilapidated condition, was vacated and the lepers were housed in temporary bamboo shacks built on the grounds of the old building.

A modern up-to-date hospital recently has been constructed at Jagubiao, between Mandawe and Consolacion, 11 kilometers from the city. The hospital occupied on May 26, 1930, was built from funds donated by Mr. Eversley Childs, of New York. The site, consisting of about 27 hectares of high ground and 26 hectares of swamp is a gift of Cebu Province. This leprosarium is officially designated the Eversley Childs Treatment Station. The new hospital is a very attractive place and will doubtless play an important rôle in the final eradication of the disease in Cebu by attracting those who previously would have hidden out.

INCIDENCE OF LEPROSY IN CEBU

Official statistics support the prevailing belief that Cebu is the most heavily infected province in the Philippines. According to the records of the Culion Leper Colony, 4,844 out of 19,100 admissions to the colony from 1906 to 1929, inclusive, were from this province. Records available at Cebu show that 5,290 lepers have been segregated from the province from 1902 to 1929, inclusive. It will be noticed that this total is larger than the Culion figure for the simple reason that it is based on the number segregated for a period of twenty-eight years, instead of only twenty-four years for Culion. In other words, for four years before the establishment of Culion, lepers were already being segregated in Cebu. Four hundred forty-six of them never reached Culion; this figure probably represents

deaths and escapes combined. Of the total number, 1,393, or almost one-fourth, came from the City of Cebu itself.

Table 5 gives the incidence based on the number of lepers collected from each of the fifty-two municipalities of the province during the period stated above, and on the estimated population of each as of December 31, 1929.

TABLE 5.—*Showing the relative incidence of leprosy based on number of lepers collected in twenty-eight years (1902-1929) per 1,000 inhabitants.*

Municipality.	Estimated population as of December 31, 1929.	Total number collected, 1902-1929.	Relative incidence per 1,000 inhabitants.
Alcantara.....	8,827	3	0.4
Alcoy.....	6,649	8	1.2
Alegria.....	14,332	26	1.8
Aloguinsan.....	14,023	68	4.9
Argao.....	41,081	102	2.5
Asturias.....	17,163	60	3.5
Badian.....	20,650	70	3.4
Balamban.....	23,428	41	1.7
Bantayan.....	15,974	84	4.7
Barili.....	34,677	139	4.0
Bogo.....	20,017	69	2.4
Boljoon.....	10,156	58	5.8
Borbon.....	12,188	23	1.9
Carcar.....	40,527	350	8.7
Carmen.....	11,166	24	2.2
Catmon.....	23,258	22	0.9
Cebu.....	78,181	1,393	17.7
Compostela.....	7,668	16	2.1
Consolacion.....	7,866	58	7.3
Cordova.....	6,110	127	20.0
Daanbantayan.....	24,819	72	2.9
Dalaguete.....	30,376	130	4.3
Danao.....	25,995	73	3.1
Dumanjug.....	24,571	45	1.8
Ginatilan.....	12,718	32	2.5
Liloan.....	13,792	65	4.4
Madrideojos.....	3,877	9	2.3
Malabuyoc.....	16,723	14	0.84
Mandawe.....	24,998	205	8.25
Medellin.....	17,795	30	1.7
Minglanilla.....	16,886	94	5.6
Moalboal.....	16,593	40	2.4
Naga.....	23,613	201	8.5
Opon.....	25,221	402	16.0
Oslob.....	13,698	39	2.9
Pilar.....	5,653	2	0.4
Pinamungajan.....	20,682	49	2.3
Poroc.....	7,690	3	0.4

TABLE 5.—*Showing the relative incidence of leprosy based on number of lepers collected in twenty-eight years (1902-1929) per 1,000 inhabitants—Continued.*

Municipality.	Estimated population as of December 31, 1929.	Total number collected, 1902-1929.	Relative incidence per 1,000 inhabitants.
Ronda.....	12,134	22	1.8
Samboan.....	13,927	12	0.9
San Fernando.....	22,819	112	4.9
San Francisco.....	12,375	30	2.4
San Remigio.....	21,091	18	0.8
Santa Fe.....	6,679	20	3.0
Santander.....	8,323	4	0.5
Sibonga.....	27,920	146	5.2
Sogod.....	9,884	15	1.5
Tabogon.....	22,272	45	2.0
Talisay.....	16,313	427	26.4
Toledo.....	31,862	111	3.4
Tuburan.....	36,721	75	2.0
Tudela.....	6,156	7	1.1
Total.....	994,365	5,290	-----

Analysis of Table 5 shows that the incidence ranges from 0.4 to 26.4 per thousand. It must be emphasized that these figures are based on total collections during a period of twenty-eight years and give only the relative incidence of the disease in the different municipalities.

A map of the province (fig. 2) indicates graphically the relative frequency of leprosy in its fifty-two municipalities. The blank spaces indicate municipalities from which an average of less than one leper was collected annually during the last twenty-eight years per 1,000 inhabitants living therein by the end of 1929; the shaded ones indicate an incidence of from 1 to 4 per 1,000; the crosshatched from 5 to 10 per 1,000; and the solid areas over 10 per 1,000. Thus, there are municipalities where the disease may be said to be nonexistent; the few cases reported from them probably came originally from the more heavily infected towns. On the other hand, there are other municipalities that have been heavily and almost alarmingly infected. Yet, all of these towns are located on a small island, apparently differing very slightly from neighboring islands in climatological characteristics, habits of the inhabitants, physiography, etc. Then again when a more minute survey of the incidence is made locally in a heavily infected municipality, this unequal distribution is again encountered, for here once more the disease is not evenly distributed throughout the population.

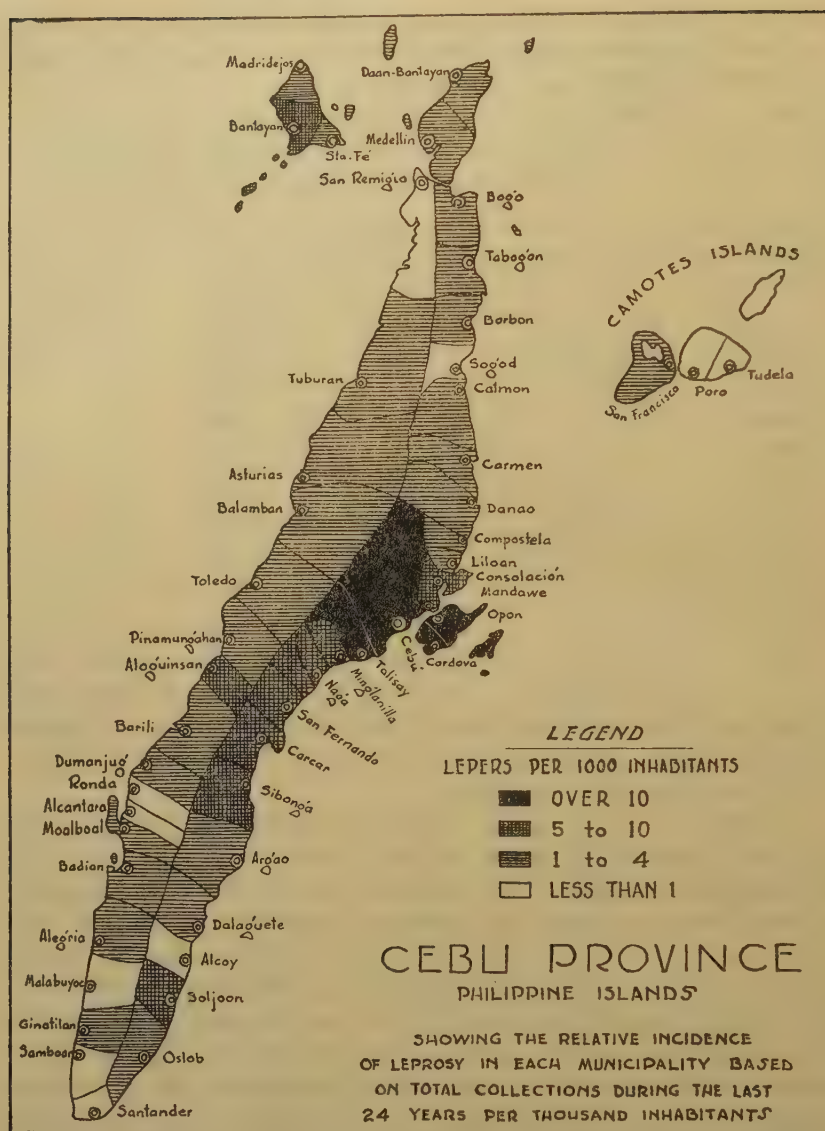


FIG. 2. Cebu Province, Philippine Islands, showing the relative incidence of leprosy in each municipality.

The lepers who have been segregated will be found to have lived almost exclusively in certain barrios or districts which are well known to the townspeople, while the rest of the municipality will be found to be practically free.

The map indicates that the principal focus of leprosy has for its center the capital itself and includes, in addition, the town of

Talisay to the south and the municipalities of Opon and Cordova, both located on Mactan Island, towards the north. The data in Table 5 tend to show that Talisay is the most heavily infected municipality, followed by Cordova, Cebu, and Opon, in the order named. The primary focus can be inclosed within a circular area with a radius of about 20 kilometers having the heart of the capital as its center. This area, with its population of 125,000 by the end of 1929, which is only about one-eighth of that of the province and about one one-hundredth of that of the Philippines, has yielded 2,349 lepers since the beginning of the segregation system in 1902, or more than two-fifths of the total collected from the province and one-eighth of all the admissions to Culion. It is probably the most important focus of leprosy in the Philippines.

From this main endemic area, the disease seems to have spread northward and southward along the narrow costal plain although it disseminated farther south than north. Northward the incidence drops off rather suddenly beyond Consolacion (12 kilometers from Cebu), while towards the south, the crosshatched area reaches as far as Carcar (40 kilometers from the capital). There appear to be isolated secondary foci at Boljoon in the south, at Alonguinsan across the island from the capital, and on Bantayan Island to the north.

It would be interesting to investigate the reasons for this striking distribution of the disease in Cebu Province. The variations in the incidence should be explained on historical grounds as well as on variations, if any, of such factors as density of population, economic condition as well as the main occupation and habits of the inhabitants, climatological differences, kind of soil, source of food, water supply, flora and fauna, etc., as found in the heavily infected areas compared with the same factors prevailing in those relatively free of the disease. However, such work, to be of any practical value, needs years of patient effort, and the results will have to be carefully sifted.

We will take up in this paper the possible influence of density of population and the climate, leaving the discussion of the other subjects to subsequent papers. It has already been stated that on historical grounds no interesting leads have been discovered so far, principally due to the absence of written records.

INFLUENCE OF DENSITY OF POPULATION ON INCIDENCE OF LEPROSY

Table 6 is shown for the purpose of indicating the possible influence of the density of population on the incidence of lep-

rosy. The figures for the incidence were obtained from Table 5, while the density was based on the population as of 1929, per hectare of cultivated territory as given in the 1918 census. It is to be regretted that it is not possible to make the latter figure up to date, but all authorities agree that there has been very little change in the area of cultivated agricultural land in Cebu since 1918.

TABLE 6.—*The relative incidence of leprosy and the density of population per hectare of cultivated territory in each municipality.^a*

Municipality. ^b	Incidence per 1,000 inhabitants.	Density of population per hectare. ^a
Alcantara.....	0.4	5.8
Alcoy.....	1.2	5.5
Alegria.....	1.8	8.9
Aloguinsan.....	4.9	4.09
Argao.....	2.5	8.9
Asturias.....	3.5	9.99
Badian.....	3.4	7.99
Balamban.....	1.7	10.8
Bantayan.....	4.7	8.4
Barili.....	4.0	11.06
Bogo.....	2.4	4.9
Boljoon.....	5.8	5.5
Borbon.....	1.9	5.6
Carcar.....	8.7	5.8
Carmen.....	2.2	4.7
Catmon.....	0.9	4.9
Cebu.....	17.7	18.7
Compostela.....	2.1	
Consolacion.....	7.3	
Cordova.....	20.0	7.3
Daanbantayan.....	2.9	6.7
Dalaguete.....	4.3	9.1
Danao.....	3.1	6.3
Dumanjug.....	1.8	6.8
Ginatilan.....	2.5	9.1
Liloan.....	4.4	2.8
Madridejos.....	2.3	8.7
Malabuyoc.....	0.84	6.9
Mandawe.....	8.25	7.3
Medellin.....	1.7	5.3
Minglanilla.....	5.6	8.9
Moalbual.....	2.4	6.8
Naga.....	8.5	6.7
Opon.....	16.0	6.1
Oslob.....	2.9	10.5

^a Population as of December 31, 1929, and area of cultivated territory as per census of 1918.

^b The municipalities of Compostela and Consolacion are not included because no data as to the area of their respective cultivated lands could be obtained.

TABLE 6.—*The relative incidence of leprosy and the density of population per hectare of cultivated territory in each municipality*^a—Ctd.

Municipality. ^b	Incidence per 1,000 inhabitants.	Density of population per hectare. ^a
Pilar.....	0.4	4.4
Pinamungajan.....	2.3	7.9
Poroc.....	0.4	3.4
Ronda.....	1.8	14.1
Samboan.....	0.9	9.5
San Fernando.....	4.9	8.1
San Francisco.....	2.4	3.1
San Remigio.....	0.8	9.9
Santa Fe.....	3.0	7.1
Santander.....	0.5	10.0
Sibonga.....	5.2	9.3
Sogod.....	1.5	1.1
Tabogon.....	2.0	5.1
Talisay.....	26.4	11.1
Toledo.....	3.4	11.1
Tuburan.....	2.0	8.35
Tudela.....	1.1	4.84

^a Population as of December 31, 1929, and area of cultivated territory as per census of 1918.

^b The municipalities of Compostela and Consolación are not included because no data as to the area of their respective cultivated lands could be obtained.

By simple inspection of the table, the relation of the density of the population to the incidence is not quite apparent, but when the data are treated biometrically to determine the degree of correlation, the result becomes clear. The calculations were made by Prof. Sofronio Balce, of the Junior College of Cebu, and confirmed by Dr. Francisco Perez, of the Department of Mathematics, College of Liberal Arts, University of the Philippines, to both of whom the writer is deeply indebted. They found the correlation coefficient to be 0.3335 ± 0.08477 , indicating a high degree of correlation.

This result corroborates the findings of Guerrero¹ who used data covering the whole Philippines by provinces. He determined the incidence by securing the number of admissions to the Culion Leper Colony from each province. Thus, the result is the same whether the calculations are based on data by provinces or narrowed down to a single province by municipalities.

Just how overcrowding favors the spread of the disease is, of course, another question. It is easy to understand that the greater the number of inhabitants in a given place, the greater

¹ Journ. Philip. Is. Med. Assoc. 7: 69.

the opportunities of spreading an infection like leprosy by contact. But when the most heavily infected sitios, barrios, or districts are surveyed, it becomes quite plain that close personal contact is not a decisive factor. This is the impression obtained when one visits the heavily infected barrios on Mactan Island where the population is dense, but the individual houses are rather evenly scattered over the territory and not closely grouped.

It may be argued that the important factor brought about by density of population is economic pressure rather than mere physical overcrowding. For this reason, the economic condition of each municipality based on yearly tax collections was correlated with the prevalence of leprosy, but no such close relation was found to exist.

INFLUENCE OF CLIMATE ON INCIDENCE OF LEPROSY

Guerrero has already called attention to the fact that the theory expressed by Rogers and Muir² that there is a close relation between heavy rainfall and high leprosy incidence, is disproved by the distribution of the disease in the Philippines. Cebu Province, the principal focus, has one of the driest climates in the Philippines. As has already been stated in the early part of this paper, the chief characteristic of the Cebu climate is the lack of variation in the temperature, rainfall, and humidity, from day to day, from month to month, and from year to year. This is also true, although to a lesser extent, with Albay and Iloilo, which also are foci of leprosy in the Philippines.

With regard to Cebu Island itself, the differences in climatic conditions between towns with marked variations in the incidence of leprosy is so slight that the climatic factor may practically be discarded as an important etiological factor. The only differences worth noting are that there is a lesser rainfall and a higher mean absolute annual range of temperature registered at Tuburan, a slightly infected town, than at the capital, which is in the center of the main focus. This shows that there is a wider variation of the yearly temperature at Tuburan, thereby again suggesting a relation between prevalence and marked regularity of the temperature.

SUMMARY

Cebu Island, located in the center of the Visayas region, constitutes the principal focus of leprosy in the Philippines and

² Leprosy. John Wright & Sons, London (1925).

is a favorable area for a thorough epidemiological study of this disease. Just how the disease was introduced into the island cannot be determined, but it is known to have spread alarmingly during the early part of the nineteenth century.

The incidence of leprosy in the fifty-two municipalities in the province varies to a remarkable degree; it ranges from an average annual collection during the last twenty-eight years of less than 1 to 26 per thousand. An effort to explain these marked differences between towns separated by only a few kilometers from one another will be the object of further studies locally.

The theory of Rogers to the effect that there is close relationship between the prevalence of leprosy and heavy rainfall is disproved in the Philippines, Cebu being one of the driest islands in the group. On the other hand, the chief characteristic of the Cebu climate is its extreme regularity throughout the year. Within Cebu Province itself, the very slight differences in temperature, rainfall, and humidity between the different municipalities, if at all significant, must play a very minor rôle in explaining the focal character of the distribution.

There is found to exist a certain correlation between density of population and prevalence of leprosy, but the nature of this relation cannot be defined at the present time.

ILLUSTRATIONS

TEXT FIGURES

- FIG. 1. Chart showing the monthly and the annual mean relative humidity of Manila and of Cebu, Philippine Islands.
2. Map of Cebu Province, Philippine Islands, showing the relative incidence of leprosy in each municipality based on total collections during the last twenty-four years per thousand inhabitants.

